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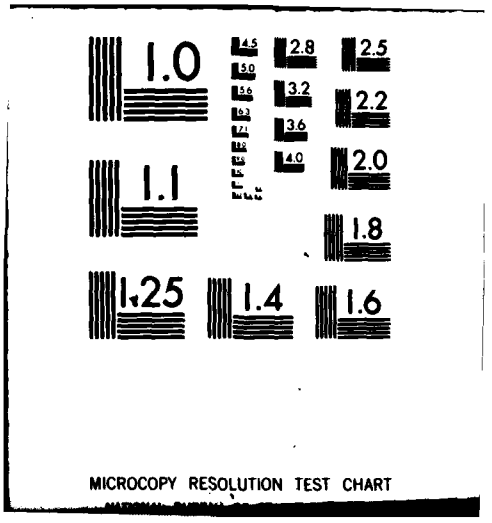
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LEVEL II

ADA082110

SUSQUEHANNA RIVER BASIN
INDIANTOWN RUN, LEBANON COUNTY

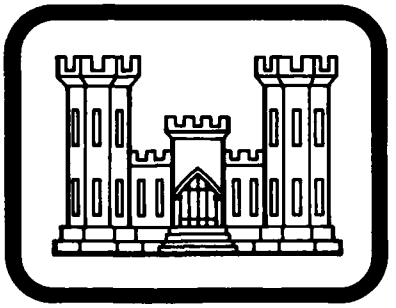
PENNSYLVANIA

RESERVATION DAM

NDI I.D. No. PA-00014
PENNDER I.D. No. 38-78

DACW 31-80-C-0016

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



PREPARED FOR

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

PREPARED BY

GAI CONSULTANTS, INC.
570 BEATTY ROAD
MONROEVILLE, PENNSYLVANIA 15146

JANUARY 1980

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topograhic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition, and the downstream damage potential.

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

ABSTRACT

Reservation Dam: NDI I.D. No. PA-00014

Owner:	Commonwealth of Pennsylvania Department of Military Affairs
State Located:	Pennsylvania (PennDER I.D. No. 38-78)
County Located:	Lebanon
Stream:	Indiantown Run
Inspection Date:	7 November 1979
Inspection Team:	GAI Consultants, Inc. 570 Beatty Road Monroeville, Pennsylvania 15146

Based on a visual inspection, operational history, and available engineering data, the dam is considered to be in good condition.

The size classification of the facility is small and its hazard classification is considered to be high. In accordance with the recommended guidelines, the Spillway Design Flood (SDF) for the facility ranges between the 1/2 PMF (Probable Maximum Flood) and the PMF. Due to the high potential for damage to downstream structures and possibly loss of life, the SDF is considered to be the PMF. Results of the hydrologic and hydraulic analysis indicate the facility will pass and/or store about 77 percent of the PMF prior to embankment overtopping. Consequently, the spillway is assessed as being inadequate, but not seriously inadequate.

Deficiencies noted by the inspection team included the following: 1) large trees rooted within the downstream embankment face; 2) a damaged and inadequate spillway discharge channel; and 3) a bent gate stem and partially obstructed outlet associated with the blowoff conduit.

It is recommended that the owner:

a. Have those trees within the downstream embankment slope removed along with their stumps. This operation should be conducted under the guidance of a soils engineer experienced in the design and construction of earth and

rockfill dams. In addition, any excessive vegetation should be trimmed to facilitate detection of any seepage or erosion on the face of the dam.

b. Retain the services of a registered professional engineer experienced in hydraulics and hydrology of dams to examine the necessity for increasing the downstream channel capacity.

c. Evaluate the outlet works and make any necessary repairs to restore the system to full operability. In addition, examine the hydraulic conditions at the outlet end of the blowoff conduit with the objective of providing unobstructed flow.

d. Develop a formal warning system for the notification of downstream occupants should hazardous embankment conditions develop. Included in the plan should be provisions for around-the-clock surveillance of the facility during periods of unusually heavy precipitation.

e. Develop formal manuals of maintenance and operation to ensure continued proper care and maintenance of the facility.

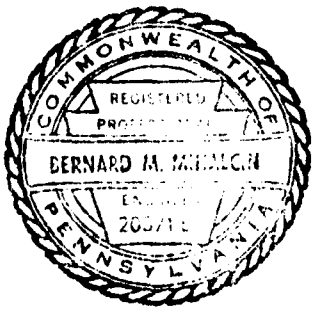
GAI Consultants, Inc.

Bernard M. Mihalcin

Bernard M. Mihalcin, P.E.

Approved by:

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer



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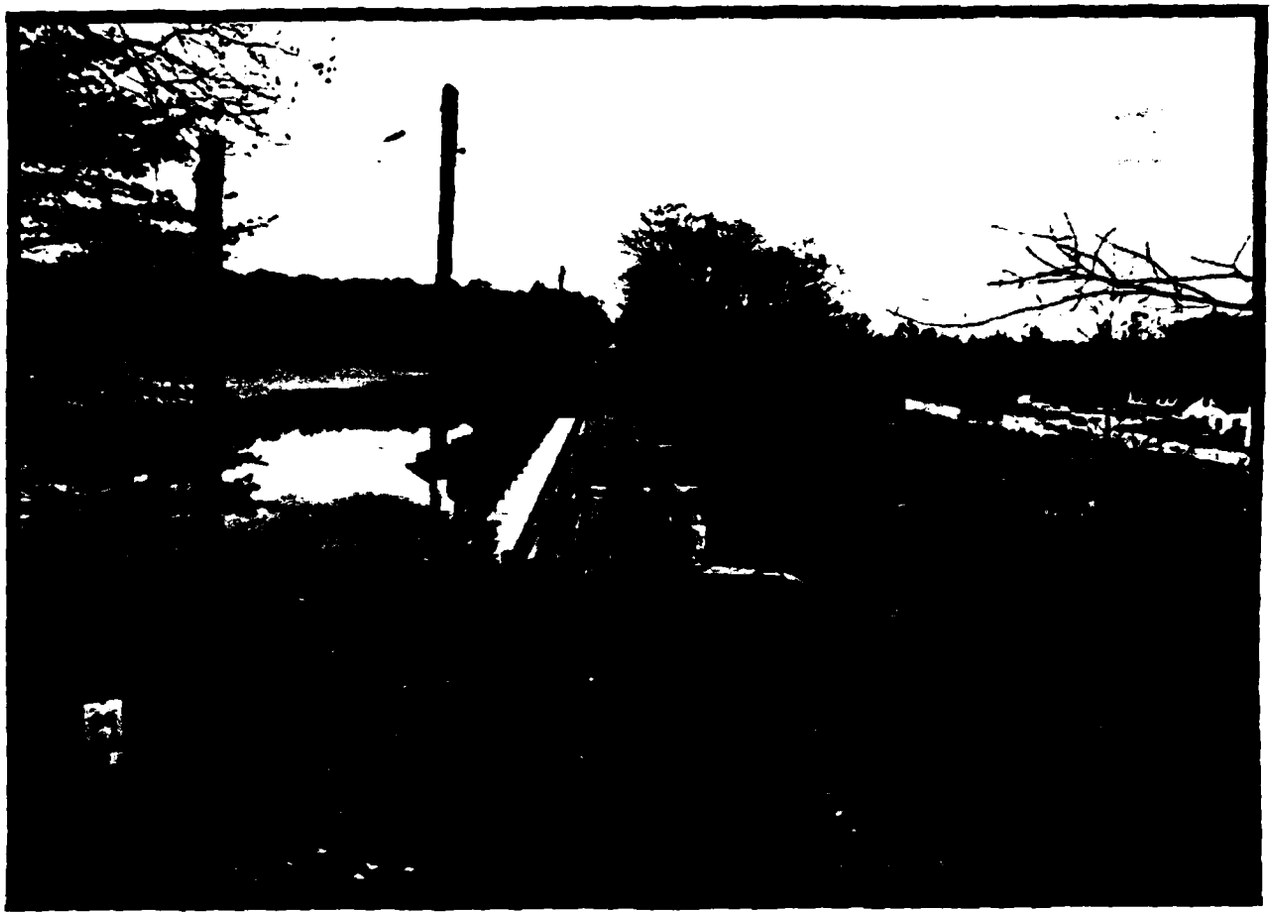

OVERVIEW PHOTOGRAPH

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NATIONAL DAM INSPECTION PROGRAM
RESERVATION DAM
(NDI PA-00014, PENNDER[redacted] Number 7-10)

Susquehanna River Basin, Indiantown Run; Lebanon County, Pennsylvania. Phase I Inspection Report.

1.0 Authority.

The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

DACW31-80-C-0016

1.1 Purpose.

The purpose is to determine if the dam constitutes a hazard to human life or property.

85 Jan 80

1.2 Description of Project.

a. Dam and Appurtenances. Reservation Dam, locally known as Marquette Lake Dam, is a zoned earth embankment approximately 27 feet high and 1065 feet long, including spillway. The facility is provided with a concrete and masonry, rectangular, chute spillway with an uncontrolled, ogee-shaped weir located at the right abutment. The spillway is divided into three bays by two masonry piers that support a steel and wood plank bridge across the structure. The effective length of the spillway crest is 99 feet with 9.2 feet clearance between the bridge support steel and the crest of the weir. The outlet works consists of a 36-inch diameter cast iron pipe (C.I.P.) blowoff line controlled by two sluice gates housed within a concrete and masonry control tower located at the upstream toe of the embankment.

b. Location. Reservation Dam is located on Indiantown Run in East Hanover Township, Lebanon County, Pennsylvania on the grounds of Indiantown Gap Military Reservation. Interchange 29 of Interstate Route 81 lies approximately two miles southeast of the facility. The dam, reservoir, and watershed are located within the Indiantown Gap and Grantville, Pennsylvania 7.5 minute U.S.G.S. topographic quadrangles (see Figure 1, Appendix E). The coordinates of the dam are N 40° 26.0' and W 76° 35.9'.

411002

c. Size Classification. Small (27 feet high, 253 acre-feet storage capacity at top of dam).

d. Hazard Classification. High (see Section 3.1.e).

e. Ownership. Commonwealth of Pennsylvania
Department of Military Affairs
Send Correspondence to:
Commanding Officer
Headquarters, United States Army
Garrison
Fort Indiantown Gap
Annville, Pennsylvania 17003

f. Purpose. Recreation.

g. Historical Data. Reservation Dam was constructed in the early 1940's in conjunction with the wartime expansion of the military complex at Fort Indiantown Gap. The military complex was originally built to serve as a troop training facility in the late 1930's. The entire Fort Indiantown Gap Military Reservation is situated on State owned land that is leased to the U.S. Army. All of the properties and facilities within the complex, including Reservation Dam, are operated and maintained by military personnel.

1.3 Pertinent Data.

a. Drainage Area (square miles). 5.8

b. Discharge at Dam Site.

Discharge Capacity of Outlet Conduit - Discharge curves are not available.

Discharge Capacity of Spillway at Maximum Pool ≅ 9870 cfs (see Appendix D, Sheet 9).

c. Elevation (feet above mean sea level). The following elevations were obtained from design drawings and field measurements based on the elevation of the spillway crest at 509 feet.

Top of Dam	518 (design) 518.5 (field)
Maximum Design Pool	Not known
Maximum Pool of Record	513.5 (June 1972)
Normal Pool	509

Spillway Crest	509
Upstream Inlet Invert	482
Downstream Outlet Invert	Not known
Downstream Embankment Toe	491.5
Streambed at Dam Centerline	488
Maximum Tailwater	Not known

d. Reservoir Length (feet).

Top of Dam	1600
Normal Pool	1100

e. Storage (acre-feet).

Top of Dam	253
Normal Pool	61
Design Surcharge	Not known

f. Reservoir Surface (acres).

Top of Dam	26
Normal Pool	15

g. Dam.

Type	Zoned earth.
Length	955 feet (excluding spillway).
Height	27 feet (field measured; crest to downstream embankment toe).
Top Width	25 feet (field). 24 feet (design).
Upstream Slope	2-1/2H:1V
Downstream Slope	2-1/2H:1V
Zoning	Figure 3 indicates embankment was designed with an impervious core composed of selected material and outer shells made up of material referred to as "earth fill".

		The downstream embankment toe is composed of rock fill.
	Cutoff	Cutoff trench, located along embankment centerline, extends five feet into the impervious base of the foundation (see Figure 3).
	Grout Curtain	None indicated.
h.	Diversion Canal and Regulating Tunnels.	None.
i.	Spillway.	
	Type	Concrete and masonry, rectangular, chute channel spillway with an uncontrolled, concrete, ogee-shaped weir located at the right abutment.
	Crest Elevation	509 feet.
	Crest Length	99 feet (excluding bridge piers).
j.	Outlet Conduit.	
	Type	36-inch diameter C.I.P. blowoff conduit.
	Length	400 feet (approximate, inlet to outlet).
	Closure and Regulating Facilities	Flow through the outlet is controlled via two sluice gates located within the control tower riser.

Access	Control tower accessible from the embankment crest via a steel and wood plank foot-bridge set on masonry piers.

SECTION 2
ENGINEERING DATA

2.1 Design.

a. Design Data Availability and Sources. No design reports or calculations are available for any aspects of the facility. Several design drawings are contained within files located at the Engineering Office of the Fort Indiantown Gap Military Reservation. Also contained within these files is a report entitled "Inspection of Marquette Dam, Fort Indiantown Gap, Pennsylvania," dated June 5, 1978. The inspection was performed on May 12, 1978 by the U.S. Army, Corps of Engineers, Baltimore District. No other reports or correspondence were made available to the inspection team.

b. Design Features.

1. Embankment. Available design drawings indicate the embankment is a zoned earth structure composed of two soil zones as shown on Figure 3. The central core is composed of material described as "Selected A-1 Material" which is flanked on both sides by outer shells composed of apparently more random material simply described as "Earth Fill." No construction specifications are available that defines these materials. A cutoff trench reportedly extends five feet into the impervious base of the foundation along the embankment centerline.

The upstream embankment face is sloped at 2-1/2H:1V and is covered between the crest and flowline by a rock riprap (see Photograph 2). The downstream slope is also set at 2-1/2H:1V and the crest width is 25 feet. The downstream embankment toe is constructed with rock fill (see Figure 3 and Photograph 4).

2. Appurtenant Structures.

a) Spillway. The spillway is a concrete and masonry, rectangular, chute channel with an uncontrolled, concrete, ogee-shaped weir located at the right abutment (see Photograph 5). The spillway is spanned by a steel and wood plank roadway bridge supported on two masonry piers. These two piers divide the spillway into three overflow bays having a total effective weir length of 99 feet (note: dimensions presented in this section are based on field measurements and do not necessarily conform with those shown on Figure 5). Spillway flows are discharged into a trapezoidal-shaped, masonry-lined channel (see Photograph 6). The channel is constructed perpendicular to the

overflow weir and carries flow parallel to the embankment toe for about 450 feet before turning downstream (see Figure 4).

b) Outlet Conduit. Design drawings (see Figure 3) indicate the outlet conduit is a 36-inch diameter C.I.P. placed below grade on a reinforced concrete saddle. Concrete cutoff collars have apparently been provided. Flow through the conduit is controlled via two sluice gates located at the control tower. The gates are operated manually from the deck of the control tower (see Figure 3; note that the control tower is constructed of masonry with a concrete deck and not solid concrete as shown. In addition, the gate house has been removed; see Photograph 10).

c. Specific Design Data and Criteria. No design reports or calculations are available for any aspect of this facility.

2.2 Construction Records.

Construction records are not available.

2.3 Operational Records.

No records of present day-to-day operation of the facility are maintained.

2.4 Other Investigations.

The facility was inspected on May 12, 1978 by the U.S. Army, Corps of Engineers (Baltimore District) resulting in a report dated June 5, 1978. This report is contained within the files located at the Engineering Office of the Fort Indiantown Gap Military Reservation.

2.5 Evaluation.

Available data pertaining to the facility is limited to several design drawings and one prior inspection report contained in the files at the Fort Indiantown Gap Military Reservation. Design drawings often conflict with as-built conditions, but nevertheless, provide some useful information. Field measurements were utilized wherever possible in the hydrologic and hydraulic analysis contained in Appendix D. The data are considered adequate to make a reasonable Phase I assessment of the facility.

SECTION 3
VISUAL INSPECTION

3.1 Observations.

a. General. The overall appearance of the facility suggests the dam and its appurtenances are currently in good condition.

b. Embankment. The embankment is considered to be in good condition although many trees cover the downstream slope of the dam (see Photograph 3). Several of these large trees (6-12 inches in diameter) have fallen; however, they have not done any significant damage to the embankment as their root systems appear shallow.

No evidence of seepage or sloughing was apparent; however, some minor ponding was observed in the area just downstream of the left abutment-embankment junction. The upstream embankment face is covered with durable sandstone riprap that is spotty in several areas. No erosion was apparent (see Photograph 2).

c. Appurtenant Structures.

1. Spillway. Visual inspection revealed the spillway to be in good condition (see Photographs 5 and 6). No evidence of physical deterioration was observed in the ogee-shaped weir, masonry piers, or adjacent concrete wingwalls. The lower downstream portion of the spillway channel was damaged by heavy discharges during the floods of June 1972 and October 1975. The extent of the damage included the displacement and loss of portions of the masonry lining along the downstream channel (see Photographs 7 and 8).

2. Outlet Conduit. The 36-inch diameter C.I.P. blowoff is reportedly functional; however, it was not operated in the presence of the inspection team. The sluice gate control mechanisms located atop the control tower riser appear to be in good condition although minor surficial corrosion is evident (see Photograph 10). It was further noted that the stem on the downstream gate was badly bent; however, both gates are reportedly operable.

Field inspection revealed that the blowoff line has been extended approximately 250 feet (Figures 2, 3, and 4 do not present as-built conditions) and exits at the base of the channel wall near the bridge shown in Photograph 11. The exit was submerged at the time of inspection; however, a hemispherical opening was observed.

d. Reservoir Area. The general area surrounding the reservoir is heavily wooded with steep slopes (see Photograph 1). No signs of slope distress were observed.

e. Downstream Channel. The stream below Reservation Dam flows in a southerly direction prior to emptying into State Memorial Lake (PennDER I.D. No. 38-80) approximately 5000 feet downstream. The area between the two facilities is relatively flat and contains numerous structures associated with Fort Indiantown Gap. Several of these structures are located immediately downstream of the dam and were flooded by several feet of water during the last major flood in 1975 (see Photograph 6). The potential for loss of life under conditions of an embankment breach is considered large even without considering the possible adverse effects such an event may have on the downstream dam at State Memorial Lake. More than a few persons generally occupy the area downstream of the dam throughout a typical day. Consequently, the hazard classification of the facility is considered to be high.

3.2 Evaluation.

The overall condition of the facility is considered to be good. The large trees observed along the downstream slope should be completely removed, including their stumps. Efforts to remove any obstruction from the discharge end of the outlet conduit and to repair the valve control mechanisms should be undertaken in order to ensure the reliability of the system. The spillway channel should be evaluated in light of the damage suffered during previous storms.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Normal Operating Procedure.

Reservation Dam is essentially a self-regulating facility. Excess inflows are automatically discharged through the spillway located at the right abutment. The blowoff is reportedly opened annually, or as needed, to ensure its operability. No formal operations manual is available.

4.2 Maintenance of Dam.

No formal maintenance program exists at this facility. Maintenance is performed on an unscheduled basis by the maintenance staff at Fort Indiantown Gap. No formal maintenance manual is available.

4.3 Maintenance of Operating Facilities.

See Section 4.2 above.

4.4 Warning System.

No formal warning system has been developed for this facility.

4.5 Evaluation.

No formal operations or maintenance manuals are available for the facility. Formal manuals are recommended to ensure the continued proper care and safe operation of the facility. In addition, no formal warning system exists.

SECTION 5
HYDROLOGIC/HYDRAULIC EVALUATION

5.1 Design Data.

No pertinent design data, calculations, or reports are available.

5.2 Experience Data.

Daily records of rainfall or spillway discharge have never been maintained at this facility. Some information pertaining to the floods of 1972 and 1975 was obtained through a review of available files and subsequent discussions with members of the engineering and maintenance staffs at the military complex. In essence, the information revealed that damage to the spillway channel was incurred in both 1972 (minor) and 1975 (more substantial). In 1972 water was reported to have been within 5 feet of the embankment crest. No estimates were given for the 1975 flood, however, it is believed to have been a lesser event. Minor flooding of the structures immediately downstream of the facility was sustained, in both cases, when water reportedly jumped the banks of the lower discharge channel.

A brief inspection report prepared by the U.S. Army, Corps of Engineers (Baltimore District) and dated June 5, 1978, states that "the spillway is capable of passing 65 percent of the PMF without overtopping the embankment. Thus, the spillway is considered inadequate, but not seriously inadequate." The report further states that "the present channel capacity is less than 15 percent of the spillway capacity and flows in excess of this amount will cause flooding in the area of the downstream toe of the dam."

5.3 Visual Observations.

On the date of inspection, no conditions were observed that would indicate the spillway would not perform satisfactorily during a flood event within the limits of its design. It was noted that base of the spillway bridge support steel is slightly below low top of dam elevation and was considered in the analysis.

5.4 Method of Analysis.

The facility has been analyzed in accordance with the procedures and guidelines established by the U. S. Army, Corps of Engineers, Baltimore District, for Phase I hydrologic and hydraulic evaluations. The analysis has been performed utilizing a modified version of the HEC-1 program developed by the U. S. Army, Corps of Engineers, Hydrologic Engineering Center, Davis, California. Analytical capabilities of the program are briefly outlined in the preface contained in Appendix D.

5.5 Summary of Analysis.

a. Spillway Design Flood (SDF). In accordance with procedures and guidelines contained in the National Guidelines for Safety Inspection of Dams for Phase I Investigations, the Spillway Design Flood (SDF) for Reservation Dam ranges between the 1/2 PMF (Probable Maximum Flood) and the PMF. This classification is based on the relative size of the dam (small), and the potential hazard of dam failure to downstream developments (high). Due to the high potential for damage to the downstream structures and possibly loss of life, the SDF for this facility is considered to be the PMF.

b. Results of Analysis. Reservation Dam was evaluated under near normal operating conditions. That is, the reservoir was initially at its normal pool or spillway elevation of 509.0 feet, with the spillway weir discharging freely. However, the outlet conduit was assumed to be non-functional for the purpose of analysis. In any event, the flow capacity of the outlet conduit is not such that it would significantly increase the total discharge capabilities of the facility. The spillway consists of a rectangular chute channel with an uncontrolled, concrete, ogee-shaped weir. All pertinent engineering calculations relative to the evaluation of this facility are provided in Appendix D.

Overtopping analysis (using the Modified HEC-1 Computer Program) indicated that the discharge/storage capacity of Reservation Dam can accommodate only about 77 percent of the PMF (SDF) prior to the overtopping of the embankment (Appendix D, Summary Input/Output Sheets, Sheet C). The peak PMF inflow of about 13,320 cfs was minimally attenuated by the storage/discharge capabilities of the dam and reservoir, such that the resulting peak PMF outflow was about 13,310 cfs (Appendix D, Sheet C). Under the PMF, the embankment would be overtopped for approximately 3.8 hours, with a maximum depth of inundation equal to about 1.0 feet above

the low top of dam elevation of 518.5 feet (Appendix D, Sheet D).

5.6 Spillway Adequacy.

Although Reservation Dam cannot accommodate its SDF (the PMF), the possible downstream consequences of embankment failure due to overtopping were not evaluated. Breaching analysis of the dam was not performed in accordance with Corps directive ETL-1110-2-234, since the facility can safely pass a flood of 1/2 PMF magnitude. Since Reservation Dam cannot accommodate a PMF-size flood, its spillway is considered to be inadequate, but not seriously inadequate.

SECTION 6
EVALUATION OF STRUCTURAL INTEGRITY

6.1 Visual Observations.

a. Embankment. Based on visual observations, the embankment appeared to be in good condition. No evidence of seepage, excess settlement, or slope erosion were observed. Large trees cover the downstream slope and are considered to be a significant deficiency as their root systems may offer a course for a possible piping problem through the embankment. Trees which may eventually uproot and topple, for whatever reason, are also a potential threat to the overall stability of the slope.

b. Appurtenant Structures.

1. Spillway. The spillway is considered to be in good condition. The lower channel, which runs approximately parallel to the downstream embankment toe, is grossly underdesigned and cannot safely accomodate the large discharges which accompany a major flood event. This deficiency threatens the safety of both the downstream embankment toe and those structures located immediately downstream of the dam. Any plans to further repair the already damaged portions of the channel should provide for its redesign so that it will at least accommodate the maximum discharge capacity of the present spillway.

2. Outlet Conduit. The outlet conduit is reportedly in good condition. The blowoff was not operated in the presence of the inspection team and consequently its present condition was not verified. The discharge end of the outlet conduit appears to be partially obstructed and should be cleared immediately.

6.2 Design and Construction Techniques.

A review on available information implies that the facility has been designed in accordance with modern accepted engineering practice. No construction records are available.

6.3 Past Performance.

Very little documented information is available from the owner and none from PennDER. Data gathered by the inspection team revealed that the embankment safely accommodated the increased stresses brought on by the last major

floods in 1972 and 1975. In 1972, water was reported to have been within 5 feet of the embankment crest. No estimates were given for the 1975 flood, however, it is believed to have been a lesser event. Minor flooding of the structures immediately downstream of the facility was sustained, in both cases, when water reportedly jumped the banks of the lower discharge channel. No other damage was reported.

6.4 Seismic Stability.

The dam is located within Seismic Zone No. 1 and it is thought that the static stability of the structure is sufficient to withstand minor earthquake-induced dynamic forces. However, no investigations or calculations were performed to confirm this belief.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS FOR REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. Based on the visual inspection and hydrologic/hydraulic analysis, the facility is considered to be in good condition.

The size classification of the facility is small and its hazard classification is considered to be high. In accordance with the recommended guidelines, the Spillway Design Flood (SDF) for the facility ranges between the 1/2 PMF (Probable Maximum Flood) and the PMF. Due to the high potential for damage to downstream structures and possibly loss of life, the SDF is considered to be the PMF. Results of the hydrologic and hydraulic analysis indicate the facility will pass and/or store about 77 percent of the PMF prior to embankment overtopping. Consequently, the spillway is assessed as being inadequate, but not seriously inadequate.

Deficiencies noted by the inspection team included the following; 1) large trees along the downstream embankment face; 2) a damaged and inadequate spillway discharge channel and; 3) a bent gate stem and partially obstructed outlet associated with the blowoff conduit.

b. Adequacy of Information. The available data are considered sufficient to make a reasonable Phase I assessment of the facility.

c. Urgency. It is suggested that the recommendations listed below be implemented as soon as possible.

d. Necessity for Additional Investigations. No additional investigations are deemed necessary at this time.

7.2 Recommendations/Remedial Measures.

It is recommended that the owner:

a. Have those trees within the downstream embankment slope removed along with their stumps. This operation should be conducted under the guidance of a soils engineer experienced in the design and construction of earth and rockfill dams. In addition, any excessive vegetation should be trimmed to facilitate detection of any seepage or erosion on the face of the dam.

b. Retain the services of a registered professional engineer experienced in hydraulics and hydrology of dams to examine the necessity for increasing the downstream channel capacity.

c. Evaluate the outlet works and make any necessary repairs to restore the system to full operability. In addition, examine the hydraulic conditions at the outlet end of the blowoff conduit with the objective of providing unobstructed flow.

d. Develop a formal warning system for the notification of downstream occupants should hazardous embankment conditions develop. Included in the plan should be provisions for around-the-clock surveillance of the facility during periods of unusually heavy precipitation.

e. Develop formal manuals of maintenance and operation to ensure continued proper care and maintenance of the facility.

APPENDIX A

VISUAL INSPECTION CHECKLIST AND FIELD SKETCHES

CHECK LIST
VISUAL INSPECTION
PHASE 1

NAME OF DAM Reservation Dam **STATE** Pennsylvania **COUNTY** Lebanon

NDI # PA — 00014 **PENNDER #** 38-78

TYPE OF DAM Earth **SIZE** Small **HAZARD CATEGORY** High

DATE(S) INSPECTION 7 November 1979 **WEATHER** Partly Cloudy **TEMPERATURE** 50° @ 1:00 p.m.

POOL ELEVATION AT TIME OF INSPECTION 509.2 **M.S.L.**

TAILWATER AT TIME OF INSPECTION N/A **M.S.L.**

INSPECTION PERSONNEL	OWNER REPRESENTATIVES	*OTHERS*
B. M. Mihalcin	U.S. Civil Service at Fort Indiantown Gap	
D. J. Spaeder	Donald Doyle (Roads and Grounds Foreman)	
D. L. Bonk		

RECORDED BY D. L. Bonk

EMBANKMENT

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00014
SURFACE CRACKS	None observed.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Horizontal - good. Vertical - good.
RIPRAP FAILURES	Riprap covering the upstream face is spotty between the control tower and left abutment. Bare soil is exposed but no apparent erosion has taken place.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Good.

EMBANKMENT

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00014
DAMP AREAS IRREGULAR VEGETATION (LUSH OR DEAD PLANTS)	Minor ponding observed at toe of left abutment-embankment junction. Possibly poor toe drainage. Downstream face is covered with large trees (12-inch diameter and less), primarily locust and maple. Several toppled trees were observed near left abutment. Root system appear to be shallow.
ANY NOTICEABLE SEEPAGE	None through embankment (see above).
STAFF GAGE AND RECORDER	None.
DRAINS	None observed.
	Rock observed exposed at right abutment. Composed primarily of shales and silty shales with near vertical bedding planes. Major joint patterns are parallel and perpendicular to the axis of the dam.

OUTLET WORKS

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00014
INTAKE STRUCTURE	Intake submerged, not observed. Masonry structure in good condition. Piers and steel bridge in good condition.
OUTLET CONDUIT (CRACKING AND SPALLING OF CONCRETE SURFACES)	None observed.
OUTLET STRUCTURE	N/A
OUTLET CHANNEL	The outlet discharges into the masonry spillway channel about 500 feet downstream of the embankment. The outlet was partially silted and fully submerged on the day of the inspection.
GATE(S) AND OPERATIONAL EQUIPMENT	Sluice gate controls exposed atop gate house. Both controls are externally corroded (minor). Downstream gate stem is severely bent. Gates are reportedly functional.

EMERGENCY SPILLWAY

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA- 00014
TYPE AND CONDITION	Masonry spillway with ogee-shaped concrete overflow crest. Divided into three bays by two masonry piers that support a wood and steel overhead roadway bridge. Good condition.
APPROACH CHANNEL	N/A
SPILLWAY CHANNEL AND SIDEWALLS	Good condition.
STILLING BASIN PLUNGE POOL	Good condition.
DISCHARGE CHANNEL	Evidence of damage to the masonry sidewalls of the channel resulting from the floods of 1972 and 1975 was observed in the channel from between 150 to 500 feet left of the overflow crest.
BRIDGE AND PIERS EMERGENCY GATES	Good condition.

SERVICE SPILLWAY

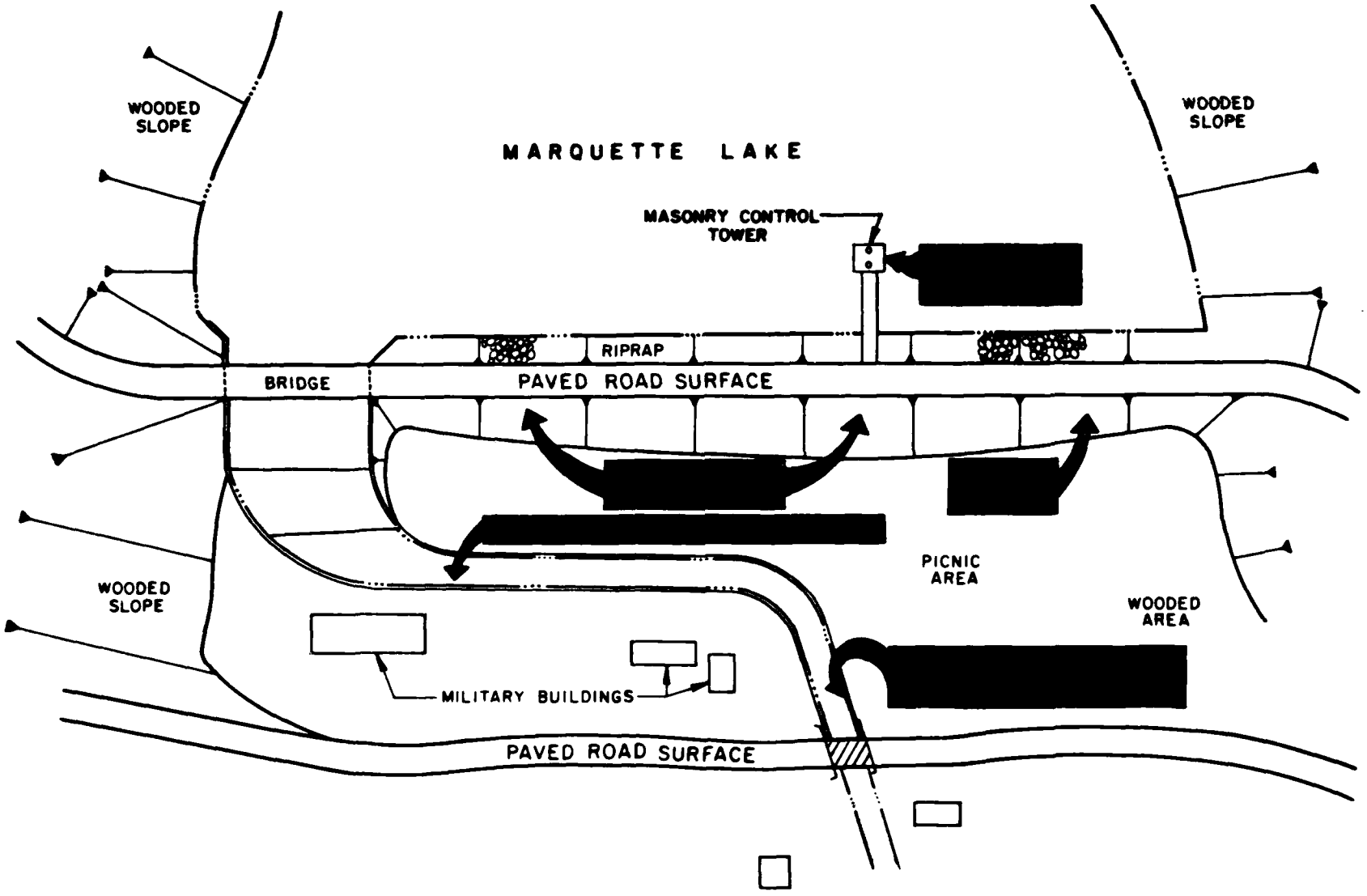
ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00014
TYPE AND CONDITION	N/A
APPROACH CHANNEL	N/A
OUTLET STRUCTURE	N/A
DISCHARGE CHANNEL	N/A

INSTRUMENTATION

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00014
MONUMENTATION SURVEYS	None.
OBSERVATION WELLS	None.
WEIRS	None.
PIEZOMETERS	None.
OTHERS	

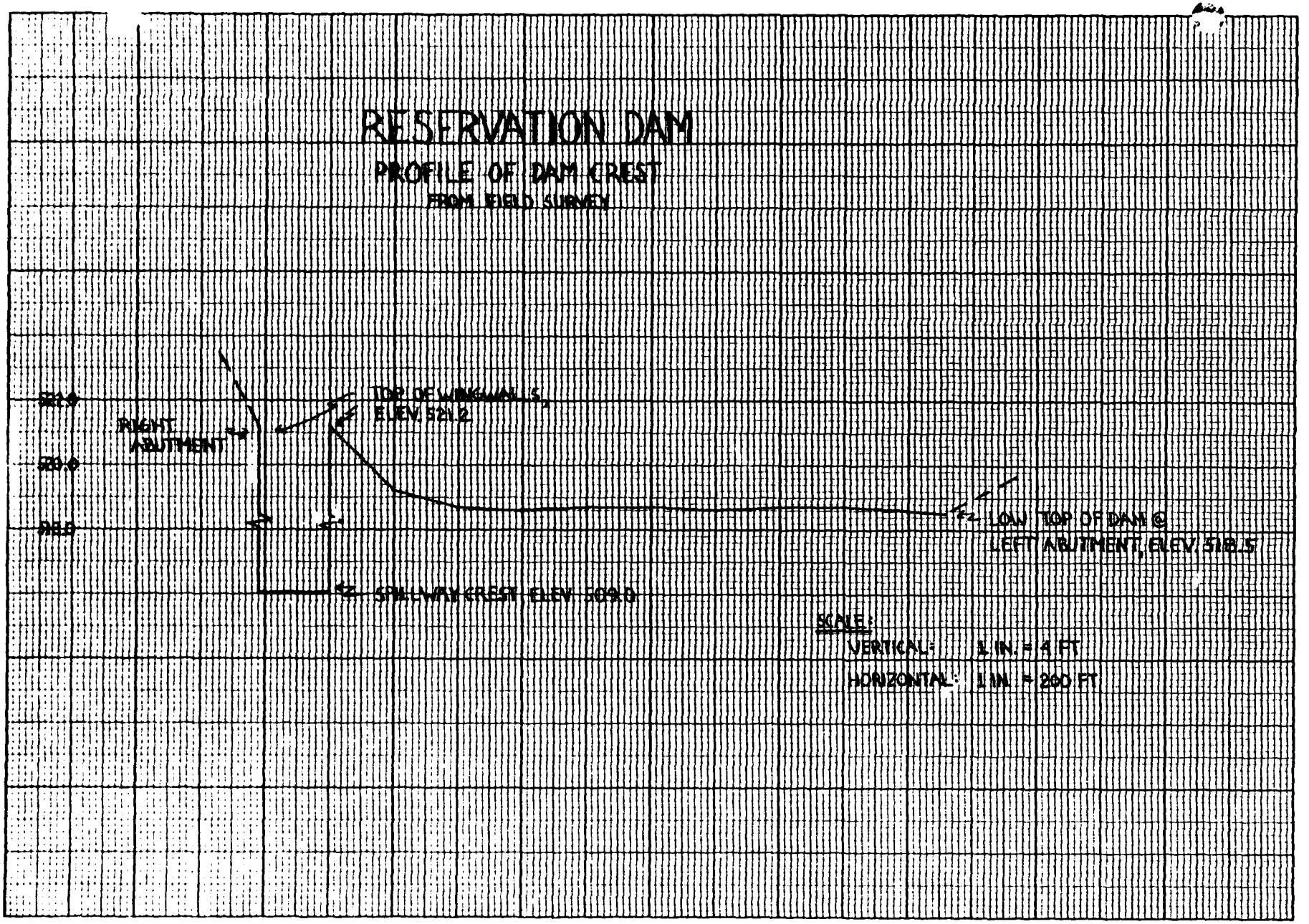
RESERVOIR AREA AND DOWNSTREAM CHANNEL

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00014
SLOPES: RESERVOIR	Steep and heavily wooded.
SEDIMENTATION	None observed.
DOWNSTREAM CHANNEL (OBSTRUCTIONS, DEBRIS, ETC.)	The stream into which the spillway discharges flows in a southerly direction prior to emptying into State Memorial Lake (PennDER I.D. No. 38-80) approximately 5,000 feet downstream.
SLOPES: CHANNEL VALLEY	Broad, flat, tree and brush covered floodplain.
APPROXIMATE NUMBER OF HOMES AND POPULATION	The area between Marquette and State Memorial Lakes contains numerous structures associated with the military complex. More than a few persons generally occupy the area downstream of the dam throughout a typical day.



RESERVATION DAM

GENERAL PLAN - FIELD INSPECTION NOTES


RESERVATION DAM
PROFILE OF DAM CREST
FROM FIELD SURVEY
522.0
520.0
518.0
RIGHT ABUTMENT
TOP OF WINGWALLS, ELEV. 521.2
LOW TOP OF DAM @ LEFT ABUTMENT, ELEV. 518.5
SPILLWAY CREST ELEV. 509.0
SCALE:
VERTICAL: 1 IN. = 4 FT
HORIZONTAL: 1 IN. = 200 FT

APPENDIX B

ENGINEERING DATA CHECKLIST

CHECK LIST
ENGINEERING DATA
PHASE I

NAME OF DAM Reservation Dam

ITEM	REMARKS NDI# PA - 00014
PERSONS INTERVIEWED AND TITLE	Walt Moyer - Deputy Director of Facilities Engineering Donald Doyle - Roads and Ground Foreman
REGIONAL VICINITY MAP	See Figure 1, Appendix E (U.S.G.S. 7.5 minute topographic quadrangles, Grantville and Indiantown Gap, Pennsylvania).
CONSTRUCTION HISTORY	Information not available. See Section 1.2.g.
AVAILABLE DRAWINGS	Four design drawings (not "as-builts") available from Fort Indiantown Gap Engineering Office. See Appendix E, Figures 2, 3, 4 and 5.
TYPICAL DAM SECTIONS	See Appendix E, Figure 3.
OUTLETS: PLAN DETAILS DISCHARGE RATINGS	See Appendix E, Figure 2. See Appendix E, Figure 3. Not available.

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS NDI# PA - 00014
SPILLWAY: PLAN SECTION DETAILS	See Appendix E, Figure 4. See Appendix E, Figure 5.
OPERATING EQUIP- MENT PLANS AND DETAILS	Not available.
DESIGN REPORTS	Not available.
GEOLOGY REPORTS	Not available.
DESIGN COMPUTATIONS: HYDROLOGY AND HYDRAULICS STABILITY ANALYSES SEEPAGE ANALYSES	Not available.
MATERIAL INVESTIGATIONS: BORING RECORDS LABORATORY TESTING FIELD TESTING	Not available.

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS	NDI# PA - 00014
BORROW SOURCES	Not known.	
POST CONSTRUCTION DAM SURVEYS	None.	
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Report dated June 5, 1978 entitled, "Inspection of Marquette Dam, Fort Indiantown Gap, Pennsylvania" by the U.S. Army, Corps of Engineers, Baltimore District, available from Fort Indiantown Gap Engineering Office.	
HIGH POOL RECORDS	Discussions with representatives of the owner indicate highest pool to have occurred in June 1972 when the level was approximately 5 feet below the embankment crest.	
MONITORING SYSTEMS	None.	
MODIFICATIONS	None recorded since original construction; however, available drawings do not depict current as-built conditions.	

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS NDI# PA - 00014
PRIOR ACCIDENTS OR FAILURES	High discharges resulting from floods in 1972 and 1975 caused damage to the lower spillway discharge channel and flooding of some of the structures located downstream.
MAINTENANCE: RECORDS MANUAL	Maintenance performed as needed. No formal records or manual are available.
OPERATION: RECORDS MANUAL	No formal records or manual are available.
OPERATIONAL PROCEDURES	No formal procedures.
WARNING SYSTEM AND/OR COMMUNICATION FACILITIES	None.
MISCELLANEOUS	

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CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

NDI ID # 00014
PENNDER ID # 38-78

SIZE OF DRAINAGE AREA: 5.8 square miles

ELEVATION TOP NORMAL POOL: 509 STORAGE CAPACITY: 61 acre-feet

ELEVATION TOP FLOOD CONTROL POOL: - STORAGE CAPACITY: -

ELEVATION MAXIMUM DESIGN POOL: - STORAGE CAPACITY: -

ELEVATION TOP DAM: 518.5 STORAGE CAPACITY: 253 acre-feet.

SPILLWAY DATA

CREST ELEVATION: 509 feet

TYPE: Rectangular chute with ogee-shaped crest

CREST LENGTH: 99 feet (excluding bridge piers)

CHANNEL LENGTH: 600 feet

SPILLOVER LOCATION: Right abutment

NUMBER AND TYPE OF GATES: None

OUTLET WORKS

TYPE: 36-diameter C.I.P. blowoff conduit

LOCATION: Approximate center of embankment

ENTRANCE INVERTS: 482 feet

EXIT INVERTS: Not known

EMERGENCY DRAWDOWN FACILITIES: Two sluice gates within control tower

HYDROMETEOROLOGICAL GAGES

TYPE: -

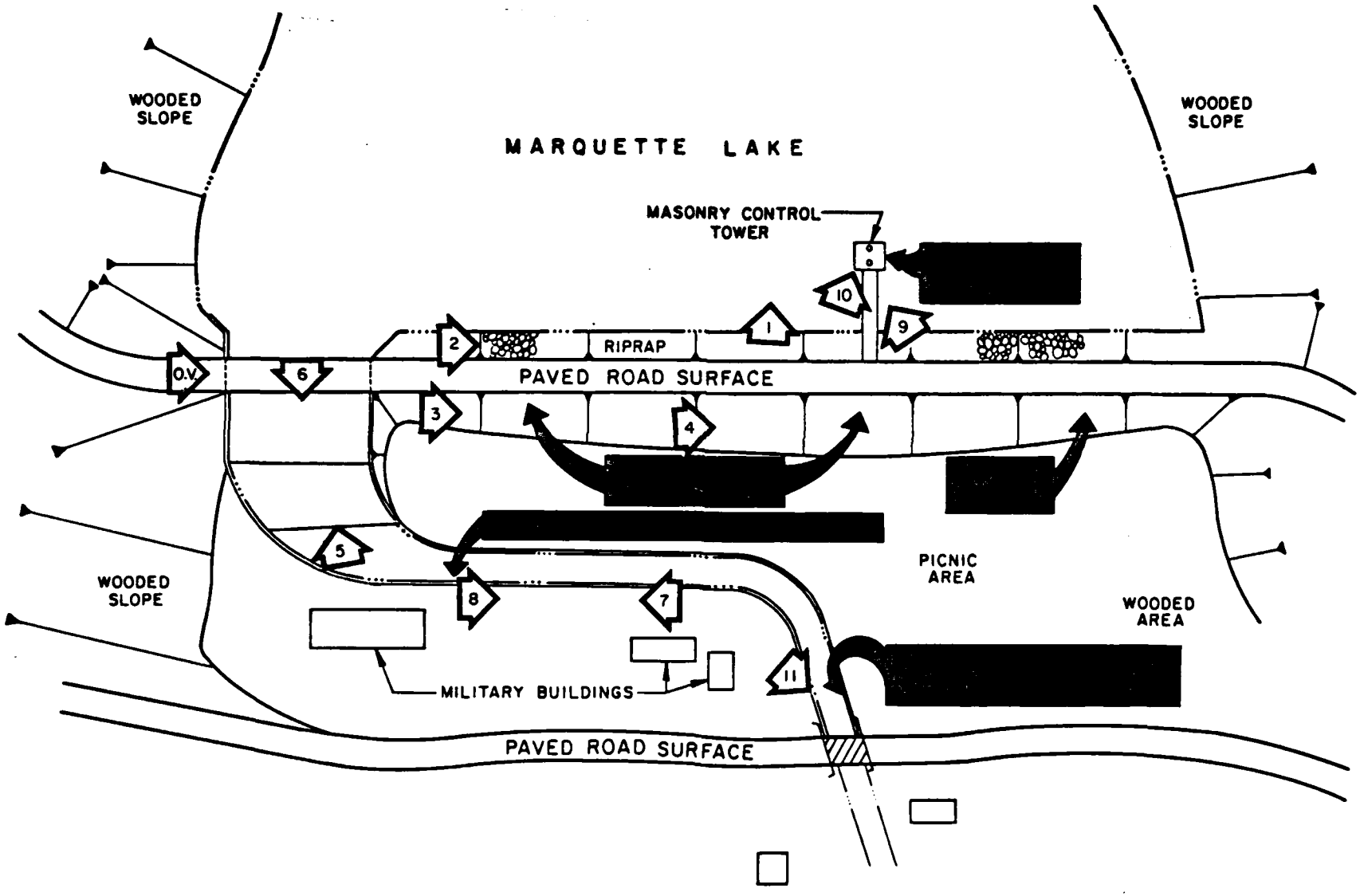
LOCATION: -

RECORDS: -

MAXIMUM NON-DAMAGING DISCHARGE: 3,200 cfs (approximate; June 1972)

APPENDIX C

PHOTOGRAPHS



RESERVATION DAM
PHOTOGRAPH KEY MAP

PHOTOGRAPH 1 View of Marquette Lake as seen from the crest of Reservation Dam.

PHOTOGRAPH 2 View of the upstream slope of Reservation Dam as seen from the right abutment.

PHOTOGRAPH 3 View of the downstream slope as seen from the right abutment.

PHOTOGRAPH 4 View of embankment showing downstream rock toe.

1

2

3

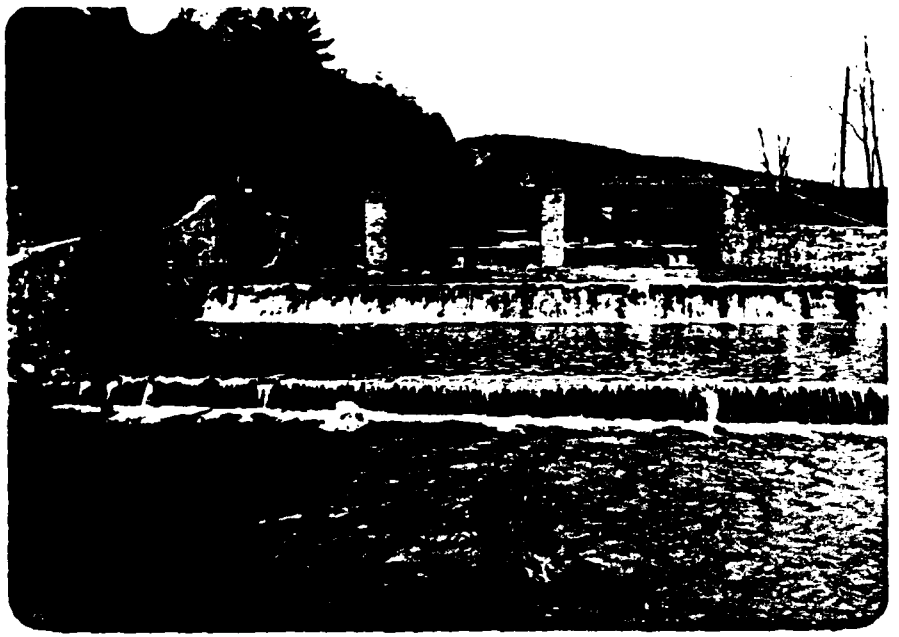
4

PHOTOGRAPH 5 View, looking upstream, of the spillway.

PHOTOGRAPH 6 View of the area immediately downstream of the embankment as seen from the spillway bridge.

PHOTOGRAPH 7 View, looking upstream, of the lower portion of the spillway discharge channel that runs approximately parallel to the downstream embankment toe.

PHOTOGRAPH 8 View of the damaged portion of the spillway discharge channel. Note that the masonry channel walls have been completely washed away in the foreground of the view.



5

6

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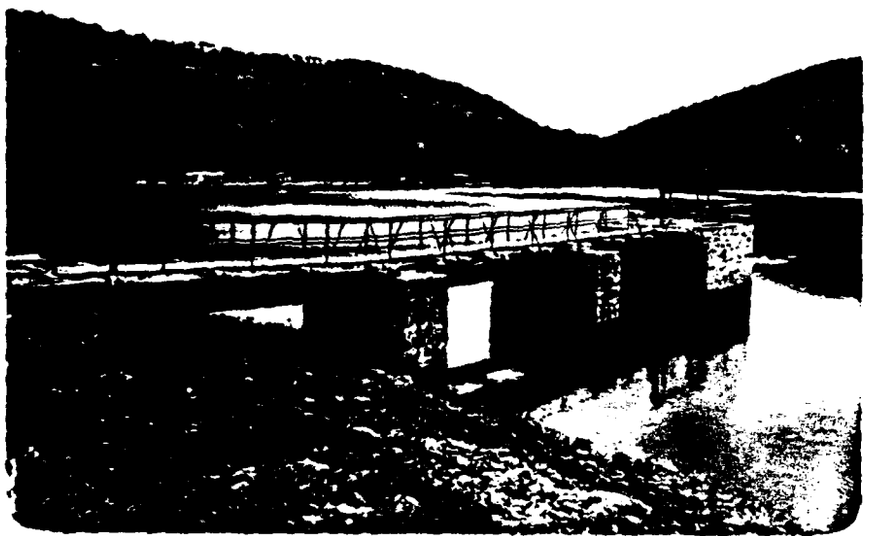
8

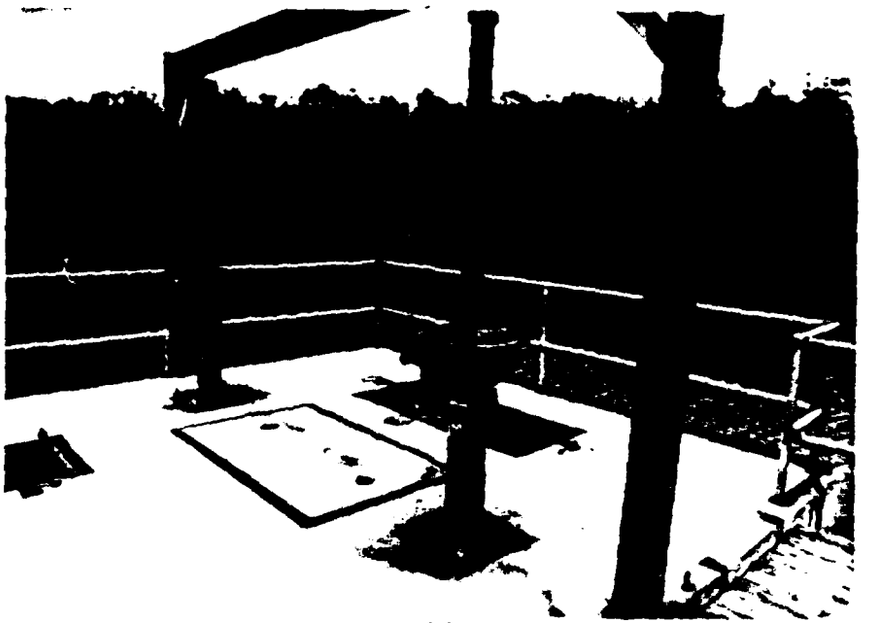
PHOTOGRAPH 9 View of the masonry control tower and access bridge.

PHOTOGRAPH 10 View of the gate control mechanisms atop the control tower. Note the surficial corrosion of the equipment.

PHOTOGRAPH 11 View of the discharge channel approximately 500 feet beyond the downstream embankment toe. Blowoff line (inundated) exits through channel wall at base.



9



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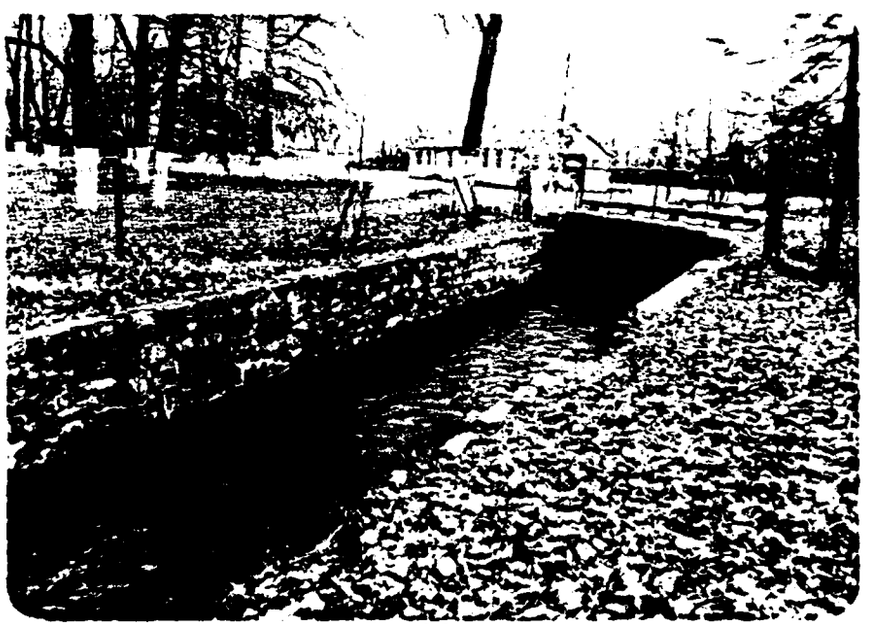

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APPENDIX D

HYDROLOGY AND HYDRAULICS ANALYSES

PREFACE

The modified HEC-1 program is capable of performing two basic types of hydrologic analyses: 1) the evaluation of the overtopping potential of the dam; and 2) the estimation of the downstream hydrologic-hydraulic consequences resulting from assumed structural failures of the dam. Briefly, the computational procedures typically used in the dam overtopping analysis are as follows:

a. Development of an inflow hydrograph(s) to the reservoir.

b. Routing of the inflow hydrograph(s) through the reservoir to determine if the event(s) analyzed would overtop the dam.

c. Routing of the outflow hydrograph(s) from the reservoir to desired downstream locations. The results provide the peak discharge(s), time(s) of the peak discharge(s), and the maximum stage(s) of each routed hydrograph at the downstream end of each reach.

The evaluation of the hydrologic-hydraulic consequences resulting from an assumed structural failure (breach) of the dam is typically performed as shown below.

a. Development of an inflow hydrograph(s) to the reservoir.

b. Routing of the inflow hydrograph(s) through the reservoir.

c. Development of a failure hydrograph(s) based on specified breach criteria and normal reservoir outflow.

d. Routing of the failure hydrograph(s) to desired downstream locations. The results provide estimates of the peak discharge(s), time(s) to peak and maximum water surface elevations of failure hydrographs for each location.

HYDROLOGY AND HYDRAULIC ANALYSIS
DATA BASE

NAME OF DAM: RESERVATION DAM

PROBABLE MAXIMUM PRECIPITATION (PMP) = 22.2 INCHES/24 HOURS (1)

STATION	1	2	3
STATION DESCRIPTION	RESERVATION DAM		
DRAINAGE AREA (SQUARE MILES)	5.8		
CUMULATIVE DRAINAGE AREA (SQUARE MILES)	-		
ADJUSTMENT OF PMF FOR DRAINAGE AREA LOCATION (%)(1)			
6 HOURS	120		
12 HOURS	130		
24 HOURS	139		
48 HOURS	145		
72 HOURS	148		
SNYDER HYDROGRAPH PARAMETERS			
ZONE (2)	15-B		
C_p (3)	0.85		
C_t (3)	2.20		
L (MILES) (4)	4.1		
L_{ca} (MILES) (4)	2.0		
$t_p = C_t (L \cdot L_{ca})^{0.3}$ (HOURS)	4.14		
SPILLWAY DATA			
CREST LENGTH (FEET)	99.0		
FREEBOARD (FEET)	9.5		

(1) HYDROMETEOROLOGICAL REPORT 40, U.S. WEATHER BUREAU, 1965.

(2) HYDROLOGIC ZONE DEFINED BY CORPS OF ENGINEERS, BALTIMORE DISTRICT, FOR DETERMINATION OF SNYDER COEFFICIENTS (C_p AND C_t).

(3) SNYDER COEFFICIENTS

(4) L = LENGTH OF LONGEST WATERCOURSE FROM DAM TO BASIN DIVIDE.
L_{ca} = LENGTH OF LONGEST WATERCOURSE FROM DAM TO POINT OPPOSITE BASIN CENTROID.

JECT DAM SAFETY INSPECTION
RESERVATION DAM

BY DJS DATE 11-12-79 PROJ. NO. 79-293-314

CHKD. BY DLB DATE 11-16-79 SHEET NO. 1 OF 12

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DAM STATISTICS

- HEIGHT OF DAM ≈ 27 FT (FIELD MEASURED)
  (FROM TOE OF EMBANKMENT TO CREST)

- ELEVATION OF TOP OF DAM: 518.0 (DESIGN; FIGURE 2)
  518.5 (FIELD)

- ELEVATION OF NORMAL POOL: 509.0 (FIGURE 3)

- UPSTREAM INLET INVERT ELEVATION:
  ≈ 482 (FIGURE 3)

- DOWNSTREAM OUTLET INVERT ELEVATION: NOT KNOWN

- DOWNSTREAM EMBANKMENT TOE: 491.5 (FIELD)

- STREAMBED ELEVATION AT DAM CENTERLINE: 488 (FIGURE 3)

- MAXIMUM POOL STORAGE CAPACITY: 903 ACRE-FT (SEE NOTE 3)
  (AT TOP OF DAM)

- NORMAL POOL STORAGE CAPACITY: ≈ 61 ACRE-FT (SEE NOTE 1)

- SURFACE AREA AT NORMAL POOL: 15 ACRES (SEE NOTE 1)

SUBJECT DAM SAFETY INSPECTION
RESERVATION DAM

BY DJS DATE 11-13-79 PROJ. NO. 79-033-214

CHKD. BY DLB DATE 11-16-79 SHEET NO. 2 OF 12

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- DRAINAGE AREA ≈ 5.8 SQUARE MILES (MEASURED ON U.S.G.S. 7.5 MINUTE QUADS; GRANTVILLE AND INDIANTOWN GAP, PA)

NOTE 1:

TAKEN FROM "DAMS, RESERVOIRS, AND NATURAL LAKES," WATER RESOURCES BULLETIN NO. 5, COMMONWEALTH OF PENNSYLVANIA, DEPT. OF FORESTS AND WATER, HARRISBURG, PA, 1972.

DAM CLASSIFICATION

SIZE: SMALL (REFERENCE 1, TABLE 1)

HAZARD CLASSIFICATION: HIGH (FIELD OBSERVED)

REQUIRED SDF: 1/2 PMF to PMF (REF. 1, TABLE 3)

HYDROGRAPH PARAMETERS

- LENGTH OF LONGEST WATERCOURSE, L, ≈ 4.1 MILES
- LENGTH OF LONGEST WATERCOURSE FROM DAM TO BASIN CENTROID, L_{CA}, ≈ 2.0 MI.

(MEASURED ON U.S.G.S. 7.5 MINUTE QUADS: GRANTVILLE AND INDIANTOWN GAP, PA)

C_t = 2.20

C_p = 0.85

(SUPPLIED BY [illegible], ZONE 15-B, SUSQUEHANNA RIVER BASIN)

JECT DAM SAFETY INSPECTION
RESERVATION DAM

BY DJS DATE 11-13-79 PROJ. NO. 79-203-314
CHKD. BY DLB DATE 11-16-79 SHEET NO. 3 OF 12

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t_p = SNYDER'S STANDARD LAG = $C_t (L \times L_{CA})^{0.3}$

$= (2.20)(4.1 \times 2.0)^{0.3} \approx \underline{4.14}$ HOURS

(NOTE : HYDROGRAPH VARIABLES USED HERE ARE DEFINED IN REFERENCE 2, IN SECTION ENTITLED "SNYDER SYNTHETIC UNIT HYDROGRAPH")

RESERVOIR SURFACE AREAS

- SURFACE AREA AT NORMAL POOL (ELEV 509.0) = 15 ACRES (NOTE 1)
- S.A. AT ELEV 520 ≈ 28 ACRES
- S.A. AT ELEV 540 = 43 ACRES

(PLANIMETERED ON U.S.G.S. 7.5 MINUTE QUADS, INDIANTOWN GAP AND GRANTVILLE, PA)

- ELEVATION OF LOW TOP OF DAM = 518.5 (FIELD NOTES)

- RATE OF S.A. INCREASE PER FOOT RISE IN RESERVOIR ELEVATION :

$$\frac{\Delta SA}{\Delta H} = \frac{28 - 15}{520 - 509} \approx \underline{1.18} \text{ AC/FT}$$

∴ SA @ ELEV 518.5 ≈ $15 + [(1.18 \text{ AC/FT})(518.5 - 509) \text{ FT}]$

≈ 26.2 ACRES

PROJECT DAM SAFETY INSPECTION
RESERVATION DAM

BY DJS DATE 11-13-79 PROJ. NO. 79-312-014

CHKD. BY DLB DATE 11-16-79 SHEET NO. 4 OF 12

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- ASSUME ZERO STORAGE AT THE BASE OF THE UPSTREAM TOE, APPROXIMATELY ELEVATION 491.0 (SEE FIGURE 3).

RESERVOIR ELEVATION - STORAGE RELATIONSHIP

- BETWEEN THE ASSUMED MINIMUM RESERVOIR ELEVATION AND NORMAL POOL ELEVATION, A LINEAR RELATIONSHIP WILL BE ASSUMED BETWEEN ELEVATION AND STORAGE.

- FOR ELEVATIONS ABOVE THAT OF NORMAL POOL, ASSUME THAT THE MODIFIED PRISMOIDAL RELATIONSHIP REPRESENTS THE CHANGES IN STORAGE VOLUME WITH INCREASE IN ELEVATION:

$$\Delta V_{1-2} = \frac{h}{3}\left(A_1 + A_2 + \sqrt{A_1 \times A_2}\right) \qquad \text{(AFE...5)}$$

WHERE ΔV_{1-2} = INCREMENTAL INCREASE IN VOLUME BETWEEN ELEVATIONS 1 & 2 (IN ACRE-FEET)

h = ELEVATION 1 − ELEVATION 2 (FT)

A_1 = SA @ ELEV 1 (ACRES)

A_2 = SA @ ELEV 2

CALCULATION OF SURFACE AREAS (SA):

$$A_i = A_o + \left[\left(\frac{\Delta SA}{\Delta H}\right)(ELEV_i - ELEV_o)\right]$$

WHERE A_i = SA @ $ELEV_i$ (ACRES)

A_o = SA @ $ELEV_o$

(BELOW ELEV 500.0, $ELEV_o$ WILL BE NORMAL POOL ELEV [illegible]
ABOVE ELEV 500.0, $ELEV_o$ WILL BE 500.0.)

$\frac{\Delta SA}{\Delta H}$ = RATE OF SA INCREASE PER FOOT RISE IN [illegible]
($\frac{3}{11}$ = .15 BELOW 500.0; $\frac{45}{55}$ = 2.75 [illegible])

PROJECT DAM SAFETY INSPECTION
RESERVATION DAM

BY DJS DATE 11-17-79 PROJ. NO. [illegible]
CHKD. BY DLB DATE 11-16-79 SHEET NO. 5 OF 12

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ELEVATION - STORAGE TABLE :

	RESERVOIR ELEVATION (FT)	A_L (ACRES)	ΔV_{1-2} (AC-FT)	TOTAL VOLUME (AC-FT)
	491.0	0	—	0
(NORMAL POOL)	509.0	15	—	61
	510.0	16	15	76
	511.0	17	16	92
	512.0	19	18	110
	513.0	20	19	129
	514.0	21	20	149
	515.0	22	21	170
	516.0	23	22	192
	517.0	24	23	215
	518.0	26	25	240

	RESERVOIR ELEVATION (FT)	A_L	ΔV_{1-2} (AC-FT)	TOTAL VOL. (AC FT)
(LOW TOE OF DAM)	518.5	26	13	253
	519.0	27	12	266
	520.0	28	27	293
	521.0	29	28	321
	522.0	29	29	350
	523.0	30	29	379
	524.0	31	30	409
	525.0	33	31	440
	530.0	35	167	607
	535.0	39	185	792
	540.0	43	205	997

PMP CALCULATIONS

- FROM REFERENCE 9, FIGURE 2, OBTAIN PMP VALUE FOR A BASIN OF DRAINAGE AREA 200 SQUARE MILES, FOR A DURATION OF 24 HOURS:

PRECIP = 22.2 INCHES

- FROM FIGURE 1, REFERENCE 9, THE ORAPHIC ADJUSTMENT [illegible] = [illegible]

- AREA CORRECTION FACTOR (REF 9) :

DURATION (HR) :	6	12	24	48	72
FACTOR ( ) :	117.5	127.0	136.0	139.5	145.0

PROJECT DAM SAFETY INSPECTION
RESERVATION DAM

BY JTJ DATE 11-13-79 PROJ. NO. 79-203-014

CHKD. BY DLB DATE 11-16-79 SHEET NO. 6 OF 12

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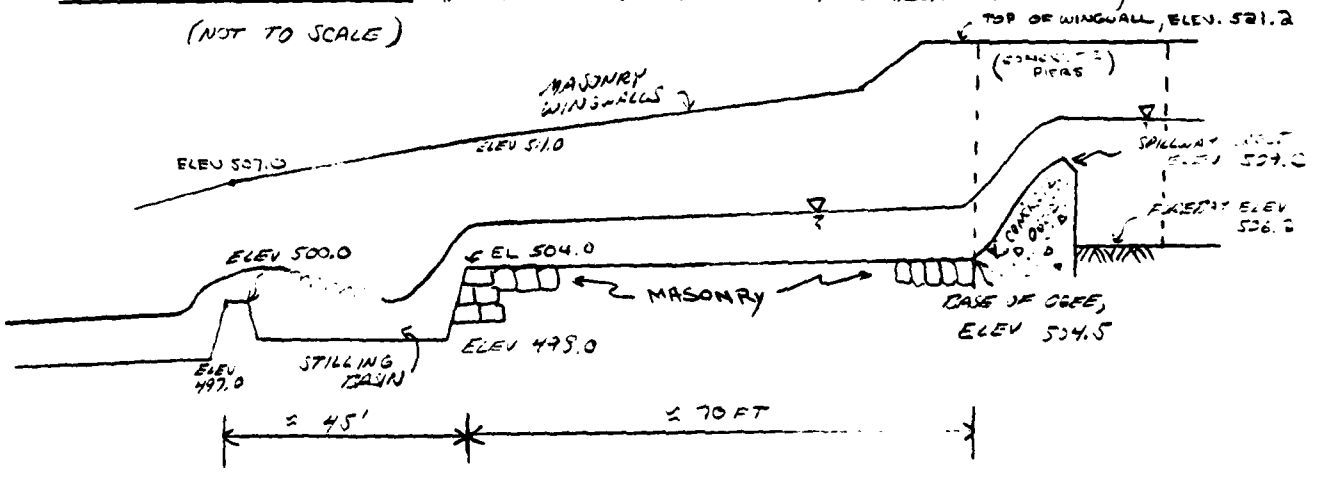
- TOTAL CORRECTION FACTOR, 1.02 x AREA CORRECTION FACTOR:

DURATION (HRS):	6	12	24	48	72
FACTOR :	120	130	139	145	148

- HOP BROOK FACTOR (ADJUSTMENT FOR BASIN SHAPE AND FOR THE LESSER LIKELIHOOD OF SEVERE STORM CENTERING OVER SMALL BASIN) FOR D.A. = 5.8 SQ. MI., IS 0.80 (REF 4, p. 48)

SPILLWAY CAPACITY

PROFILE OF SPILLWAY (FROM FIELD MEASUREMENTS AND DESIGN DRAWINGS):
(NOT TO SCALE)



PROJECT DAM SAFETY INSPECTION
RESERVATION DAM

BY [illegible] DATE 11-13-79 PROJ. NO. 79-802-214

CHKD. BY DLB DATE 11-16-79 SHEET NO. 7 OF 12

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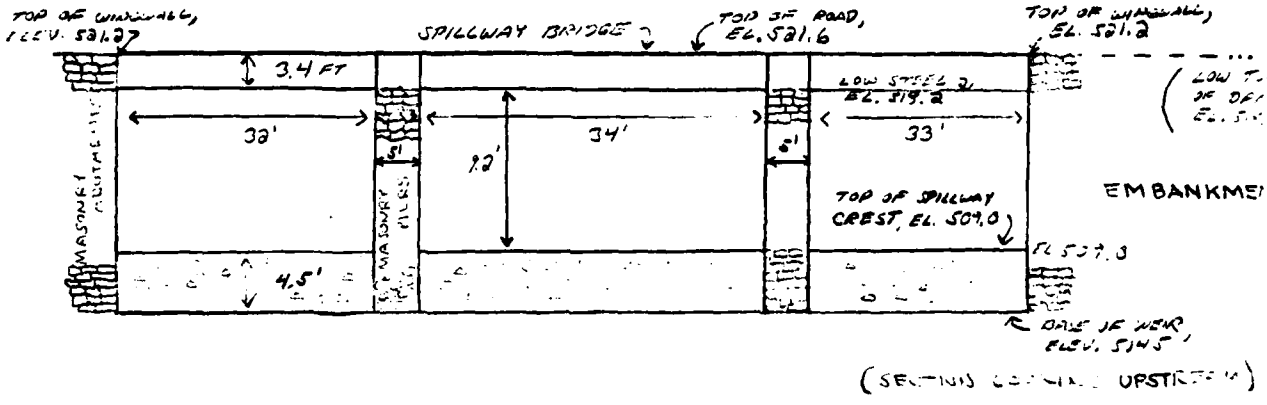
CROSS-SECTION OF SPILLWAY (FROM FIELD MEASUREMENTS)
(NOT TO SCALE)



- THE SPILLWAY CONSISTS OF A RECTANGULAR CHUTE CHANNEL WITH AN UNCONTROLLED CONCRETE OGEE-SHAPED WEIR. APPROACH LOSSES ARE [illegible] NEGLIGIBLE HERE. FOR RESERVOIR ELEVATIONS BELOW 518.2, (H ≤ 9.2 FT), THE DISCHARGE IS GIVEN BY THE EQUATION

$$Q = CLH^{3/2}$$ (REF 4, p. 373)

WHERE Q = DISCHARGE (IN CFS)
C = COEFFICIENT OF DISCHARGE (VARIABLE)
L = EFFECTIVE LENGTH OF CREST (FT)
H = HEIGHT OF RESERVOIR ABOVE SPILLWAY CREST (FT)

- THE EFFECTIVE LENGTH OF THE SPILLWAY CREST IS 99.0 FEET. FOR PIERS OTHER THAN POINTED-NOSE PIERS, A REDUCTION FACTOR IS NORMALLY USED TO ACCOUNT FOR SIDE CONTRACTION OF FLOW. HOWEVER, SINCE THERE ARE POINTED-NOSE PIERS USED HERE, THE REDUCTION FACTOR IS ZERO. (REF 4, p. 373)

JECT DAM SAFETY INSPECTION
RESERVATION DAM

BY DTS DATE 11-17-79 PROJ. NO. 79-207-214

CHKD. BY DLB DATE 11-16-79 SHEET NO. 8 OF 12

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- THE DESIGN TOP OF DAM ELEVATION, AS SHOWN IN FIGURE 2, CORRESPONDS TO THE DESIGN TOP OF WINGWALL ELEVATION 518.0. FIELD MEASUREMENTS INDICATE THE PRESENT TOP OF WINGWALL ELEVATION TO BE SET AT 521.2 FEET. IT CAN LOGICALLY BE ASSUMED THAT THE DESIGN WAS ALTERED, AT SOME POINT, TO ACCOMMODATE THE BRIDGE ACROSS THE SPILLWAY AND THE ASPHALT ROAD SURFACE ATOP THE EMBANKMENT. THUS, FOR THE PURPOSE OF ANALYSIS, THE ELEVATION OF THE LOW CHORD OF THE BRIDGE, 518.2, IS ASSUMED TO REPRESENT THE DESIGN HEAD ELEVATION. FOR HEADS OTHER THAN THAT OF DESIGN HEAD, THE DISCHARGE COEFFICIENT, C, MUST BE MODIFIED, TO ACCOUNT FOR REDUCED FLOWS BELOW DESIGN HEAD, AND INCREASED FLOWS ABOVE DESIGN HEAD. APRON AND SUMBERGENCE EFFECTS ARE ASSUMED TO BE NEGLIGIBLE HERE, FROM INSPECTION OF DOWNSTREAM CONDITIONS.

P = FOREDAY DEPTH = 2.8 FT (FIELD MEASURED)

H_o = ASSUMED DESIGN HEAD = 518.2 - 509.0 = 9.2 FT

$P/H_o = 2.8/9.2 \approx 0.304$, $\therefore C_o \approx 3.69$ (REF. 4, p. 378, Fig 3-4)

SPILLWAY RATING CURVE FOR ELEVATIONS BELOW LOW CHORD OF BRIDGE:

RESERVOIR ELEV (FT)	H (FT)	H/Ho	① C/Co	② C	③ Qtot (CFS)
509.0	—	—	—	—	0
510.0	1	0.11	0.82	3.03	300
511.0	2	0.22	0.86	3.17	890
512.0	3	0.33	0.88	3.25	1670
513.0	4	0.43	0.91	3.36	2660
514.0	5	0.54	0.93	3.43	3800
515.0	6	0.65	0.95	3.51	5110
516.0	7	0.76	0.97	3.58	6560
517.0	8	0.87	0.98	3.62	8110
518.0	9	0.98	0.99	3.65	9760
518.2	9.2	1.00	1.0	3.69	10,190

① C/C_o TAKEN FROM FIG 3-4 REF. 4 (p. 378)

② $C = C/C_o \times 3.69$

③ $Q_{TOT} = CLH^{3/2}$

[illegible]JECT	DAM SAFETY INSPECTION RESERVATION DAM
BY: [illegible]	DATE: [illegible]
PROJ. NO.: 79-303-014	
CHKD. BY: DLB	DATE: 11-16-79
SHEET NO.: 9	OF: 12

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- FOR RESERVOIR ELEVATIONS ABOVE 518.2 AND BELOW 591.6, THE DISCHARGE UNDER THE LOW CHORD OF THE BRIDGE WILL ESSENTIALLY BE ORIFICE FLOW (SLUICE FLOW):

$$Q = \tfrac{2}{3}\sqrt{2g}\, CL\,(H_1^{3/2} - H_2^{3/2}) \qquad \text{(REF 4, p. 3[illegible])}$$

WHERE
- Q = FLOW THROUGH A LOW-HEAD ORIFICE (CFS)
- C = COEFFICIENT OF DISCHARGE
- L = LENGTH (OF CREST) ≈ 99 FT
- H_1 = TOTAL HEAD ON BOTTOM OF ORIFICE ≈ ELEV$_i$ − 509.0
- H_2 = TOTAL HEAD ON TOP OF ORIFICE ≈ ELEV$_i$ − 519.2

SPILLWAY RATING CURVE FOR ORIFICE FLOW:

RESERVOIR ELEVATION ([illegible])	H_1 (FT)	H_2 (FT)	$D = H_1 - H_2$ (FT)	[illegible]	C	Q = [illegible] $\sqrt{2g}$ CL ([illegible])
518.5	9.5	0.3	9.2	0.97	[illegible]	9870
518.7	[illegible]7	0.5	9.2	0.15	[illegible]	13,180
519.0	[illegible]0	0.8	9.2	0.12	[illegible]	10,480
5[illegible]	[illegible]0	1.8	9.2	0.84	[illegible]	11,550
5[illegible]	[illegible]	2.8	[illegible]	0.77	0.64	12,500
5[illegible] *	[illegible]	3.8	[illegible]	0.71	[illegible]	[illegible] 570
5[illegible]	[illegible]	4.8	[illegible]	0.66	[illegible]	[illegible],410
594.0	[illegible]	[illegible]	[illegible]	0.61	[illegible]	15,430
5[illegible]	[illegible]	[illegible]	9.2	0.5[illegible]	[illegible]	16,170

C FROM [illegible] 1.57, p. [illegible] : [illegible]
[illegible] WEIR [illegible] : [illegible]

* — ABOVE ELEVATION 591.6, WEIR FLOW [illegible] THE BRIDGE. (SEE [illegible])

SUBJECT DAM SAFETY INSPECTION
RESERVATION DAM

BY DJS DATE 11-14-79 PROJ. NO. 79-2-13-014

CHKD. BY DLB DATE 11-16-79 SHEET NO. 10 OF 12

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- FOR DISCHARGE OVER THE SPILLWAY BRIDGE, USE RELATIONSHIP FOR A BROAD-CRESTED WEIR:

$$Q = CLH^{3/2} \qquad \text{(REF 5, p. 5-33)}$$

WHERE Q = DISCHARGE OVER WEIR (CFS)
L = LENGTH OF WEIR = 109 FT
H = TOTAL HEAD ON WEIR
= RESERVOIR ELEV − 531.6
C = DISCHARGE COEFFICIENT = 2.63 (REF 5, p. 5-43)

RATING CURVE FOR DISCHARGE OVER SPILLWAY BRIDGE:

RESERVOIR ELEVATION (FT)	H (FT)	$Q_{\text{BRIDGE}} = CLH^{3/2}$ (CFS)	$Q_{\text{TOTAL}} = Q_{\text{BRIDGE}} + Q_{\text{DAM}}$ (CFS)
532.0	0.4	70	13,660
533.0	1.4	470	14,880
534.0	2.4	1070	16,500
535.0	3.4	1800	17,970

RATING CURVE FOR DAM EMBANKMENT

- ASSUME THAT THE EMBANKMENT ACTS ESSENTIALLY AS A BROAD-CRESTED WEIR WHEN OVERTOPPED. THUS, THE FLOW WILL BE DEFINED BY THE RELATIONSHIP

$$Q = CLH^{3/2} \qquad \text{(SEE ABOVE)}.$$

IECT DAM SAFETY INSPECTION
RESERVATION DAM

BY DTS DATE 11-14-79 PROJ. NO. 79-303-014

CHKD. BY DLB DATE 11-16-79 SHEET NO. 11 OF 12

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— FIRST, FIND LENGTH OF EMBANKMENT SUBMERGED FOR VARIOUS RESERVOIR ELEVATIONS:

RESERVOIR ELEVATION (FT)	APPROXIMATE LENGTH OF EMBANKMENT SUBMERGED (FT)	
518.5 (LOW POINT OF DAM)	0	
518.7	620	(TAKEN FROM FIELD NOTES
519.0	890	AND USGS INDIANTOWN SW 7½')
520.0	1040	
522.0	1240	
525.0	1500	

— ASSUME INCREMENTAL DISCHARGES OVER EMBANKMENT ARE APPROXIMATELY TRAPEZOIDAL IN CROSS-SECTION. INCREMENTAL AREA OF FLOW $\simeq H_i\left[(L_1+L_2)/2\right]$. THEREFORE, THE TOTAL AVERAGE FLOW-AREA WEIGHTED HEAD, $H_{w\text{-}T}$, $\simeq$ TOTAL FLOW AREA $/ L_2$.
(L_1 = LENGTH AT LOWER ELEVATION, L_2 = LENGTH AT HIGHER ELEVATION)

RESERVOIR ELEV (FT)	L_1 (FT)	L_2 (FT)	INCREMENTAL HEAD, H_i (FT)	① INCR. FLOW AREA A_i (FT²)	TOTAL FLOW AREA, A_T (FT²)	② TOTAL WTD HEAD $H_{w\text{-}T}$ (FT)	③ $H_{w\text{-}T}/l$	④ C	⑤ Q (CFS)
518.5	—	—	—	—	—	—	—	—	—
518.7	0	620	0.2	62	62	0.1	0.0	2.72	60
519.0	620	890	0.3	227	289	0.3	0.0	2.79	440
520.0	890	1040	1.0	965	1254	1.2	0.0	3.24	4160
522.0	1040	1240	2.0	2280	3534	2.9	0.12	3.25	15,700
525.0	1240	1500	3.0	4110	7644	5.1	0.20	3.33	57,100

① $A_i = \left(\frac{L_1+L_2}{2}\right)H_i$

② $H_{w\text{-}T} = A_T/L_2$

③ l = BREADTH OF CREST = 25 FT

④ C, DISCHARGE COEFFICIENT, TAKEN FROM REF 12, FIG. 34

⑤ $Q = CL_2 H_{w\text{-}T}^{3/2}$

SUBJECT DAM SAFETY INSPECTION
RESERVATION DAM

BY DJS DATE 11-14-79 PROJ. NO. 79-322-014

CHKD. BY DLB DATE 11-16-79 SHEET NO. 12 OF 12

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TOTAL FACILITY RATING CURVE

$Q_{TOTAL} = Q_{SPILLWAY} + Q_{EMBANKMENT}$

($Q_{SPILLWAY}$ TAKEN FROM SHEETS 8, 9, & 10; $Q_{EMBANKMENT}$ FROM SHEET 11.)

RESERVOIR ELEVATION (FT)		$Q_{SPILLWAY}$ (CFS)	$Q_{EMBANKMENT}$ (CFS)	Q_{TOTAL} (CFS)
509.0	(SPILLWAY CREST)	0		0
510.0		300		300
511.0		890		890
512.0		1670		1670
513.0		2660		2660
514.0		3800		3800
515.0		5110		5110
516.0		6560		6560
517.0		8110		8110
518.0		9760		9760
518.5	(LOW TOP OF DAM)	9870	0	9870
518.7		10,120	60	10,180
519.0		10,480	440	10,920
520.0		11,550	4160	15,710
521.0		12,500	8800 *	21,300
522.0		13,660	18,700	32,360
523.0		14,880	26,000 *	40,880
524.0		16,500	37,000 *	53,500
525.0		17,970	53,200	71,170

* INTERPOLATED, SEMI-LOG PLOT.

SUBJECT DAM SAFETY INSPECTION

RESERVATION DAM

BY RJS DATE 12-3-79 PROJ. NO. 79-336-314

CHKD. BY RLB DATE 12-5-79 SHEET NO. A OF D

OVERTOPPING

SUMMARY INPUT/OUTPUT SHEETS

DAM SAFETY INSPECTION
RESERVATION DAM ******** OVERTOPPING ANALYSIS ********
15-MINUTE TIME STEP AND 72-HOUR STORM DURATION

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPNT	NSTAN
288	0	15	0	0	0	0	0	0	0

JOPER	NRT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 5 LRTIO= 1
RTIOS= .50 .60 .70 .80 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW INTO RESERVOIR

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	5.80	0.00	5.80	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	22.20	120.00	130.00	139.00	145.00	148.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

INITIAL AND CONSTANT RAINFALL LOSSES; COE.

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

BASE FLOW [illegible]; COE.

UNIT HYDROGRAPH DATA
TP= 4.14 CP= .85 RTA= 0

RECESSION DATA
STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

CLARK DID NOT CONVERGE TO GIVEN SNYDER COEFFICIENTS
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=25.41 AND R= 3.97 INTERVALS

UNIT HYDROGRAPH 39 END-OF-PERIOD ORDINATES, LAG= 4.09 HOURS, CP= .82 VOL= 1.00

18.	66.	128.	194.	261.	326.	389.	449.	506.	560.
611.	660.	705.	741.	763.	771.	769.	758.	739.	714.
683.	646.	602.	550.	487.	403.	317.	248.	194.	152.
119.	94.	73.	58.	45.	35.	28.	22.	17.	

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SUBJECT DAM SAFETY INSPECTION

RESERVATION DAM

BY JJC DATE 12-3-79 PROJ. NO. 79-203-01A

CHKD. BY DLB DATE 12-5-79 SHEET NO. B OF D

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O HO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	HO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.20	23.66	2.62	357260.
										(666.)(601.)(67.)(10116.48)			

INFLOWS INTO RESERVOIR

PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	13324.	10683.	3646.	1240.	357240.
CMS	377.	302.	103.	35.	10116.
INCHES		17.13	23.39	23.87	23.87
MM		435.10	594.13	606.38	606.38
AC-FT		5297.	7232.	7381.	7381.
THOUS CU M		6534.	8920.	9104.	9104.

0.7 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9327.	7478.	2552.	868.	250068.
CMS	264.	212.	72.	25.	7081.
INCHES		11.99	16.37	16.71	16.71
MM		304.63	415.89	424.47	424.47
AC-FT		3708.	5062.	5167.	5167.
THOUS CU M		4574.	6244.	6373.	6373.

0.8 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10659.	8546.	2917.	992.	285792.
CMS	302.	242.	83.	28.	8093.
INCHES		13.71	18.71	19.10	19.10
MM		348.15	475.30	485.11	485.11
AC-FT		4238.	5785.	5905.	5905.
THOUS CU M		5227.	7136.	7283.	7283.

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE THROUGH RESERVOIR

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	101	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.0	0.000	0.00	1	1	0	0		0
	NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
	1	0	0	0.000	0.000	0.000	61.	-1

STAGE	509.00	510.00	511.00	512.00	513.00	514.00	515.00	516.00	517.00
	518.50	518.70	519.00	520.00	521.00	522.00	523.00	524.00	525.00
FLOW	0.00	300.00	890.00	1670.00	2660.00	3800.00	5110.00	6560.00	8110.00
	9870.00	10180.00	10920.00	15710.00	21300.00	32360.00	40840.00	51500.00	71170.00

SUBJECT DAM SAFETY INSPECTION

RESERVATION DAM

BY BTS DATE 8-3-79

CHKD. BY DLG DATE 12-3-79

PROJ. NO. 79-832-314

SHEET NO. 5 OF D

CAPACITY=	0.	61.	76.	92.	110.	129.	149.	170.	192.	215.
	240.	253.	266.	293.	321.	350.	379.	409.	440.	607.
ELEVATION=	491.	509.	510.	511.	512.	513.	514.	515.	516.	517.
	518.	519.	519.	520.	521.	522.	523.	524.	525.	530.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
509.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
518.5	0.0	0.0	0.

RESERVOIR OUTFLOW HYDROGRAPHS

OVERTOPS @ 0.77 PMF

PEAK OUTFLOW IS 13310. AT TIME 43.25 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	13310.	10665.	3645.	1240.	357125.
CMS	377.	302.	103.	35.	10113.
INCHES		17.11	23.39	23.87	23.87
MM		434.48	594.02	606.19	606.19
AC-FT		5289.	7230.	7379.	7379.
THOUS CU M		6523.	8919.	9101.	9101.

PMF

PEAK OUTFLOW IS 9299. AT TIME 43.50 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9299.	7464.	2582.	868.	249985.
CMS	263.	211.	73.	25.	7079.
INCHES		11.97	16.37	16.71	16.71
MM		304.06	415.81	424.33	424.33
AC-FT		3701.	5061.	5165.	5165.
THOUS CU M		4565.	6243.	6371.	6371.

0.7 PMF

PEAK OUTFLOW IS 10636. AT TIME 43.50 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10636.	8531.	2916.	992.	285695.
CMS	301.	242.	83.	28.	8090.
INCHES		13.68	18.71	19.09	19.09
MM		347.53	475.20	484.94	484.94
AC-FT		4230.	5784.	5903.	5903.
THOUS CU M		5218.	7135.	7281.	7281.

0.8 PMF

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SUBJECT DAM SAFETY INSPECTION

RESERVATION DAM

BY DJJ DATE 12-3-79 PROJ. NO. 79-303-014

CHKD. BY DLB DATE 12-3-79 SHEET NO. D OF D

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SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	509.00	509.00	518.50
STORAGE	61.	61.	253.
OUTFLOW	0.	0.	9870.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	516.05	0.00	193.	6643.	0.00	43.50	0.00
.60	516.91	0.00	213.	7971.	0.00	43.50	0.00
.70	517.72	0.00	233.	9299.	0.00	43.50	0.00
.77*	518.50	—	253	9870	—	—	—
.80	518.88	.38	263.	10636.	1.50	43.50	0.00
1.00	519.50	1.00	279.	13310.	3.75	43.25	0.00

* BY INTERPOLATION; OVERTOPPING OCCURS AT APPROXIMATELY 0.77 PMF.

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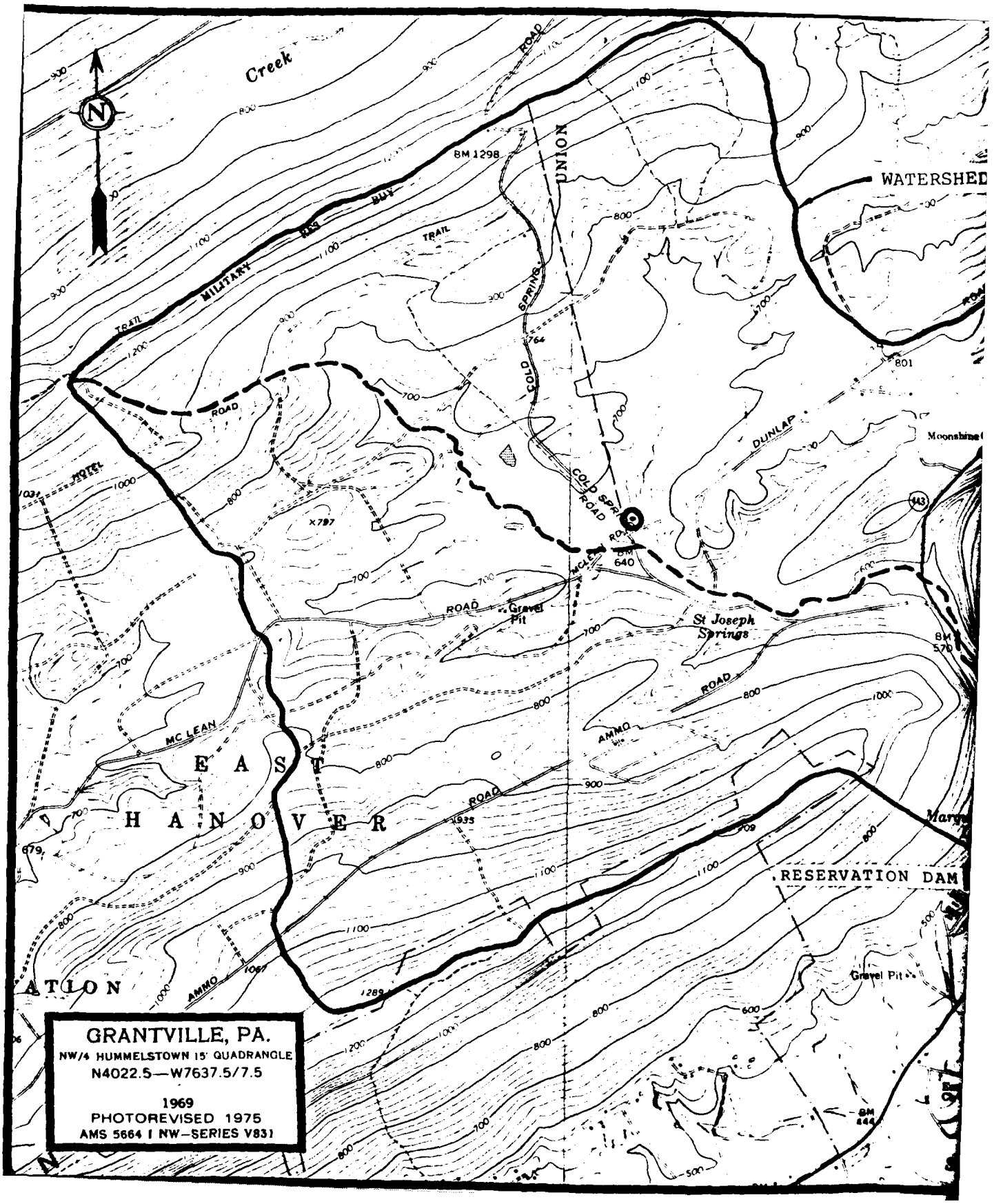
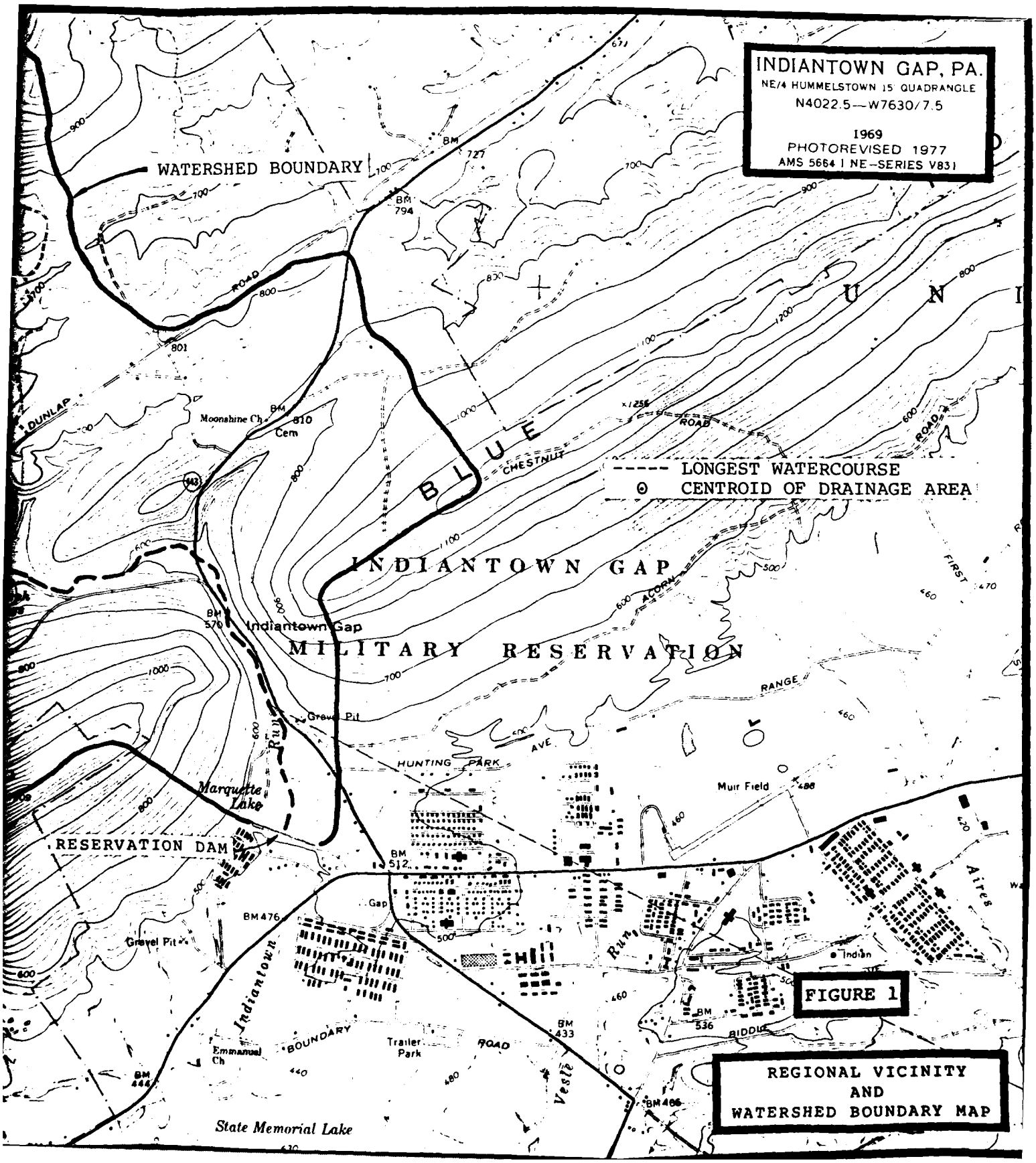
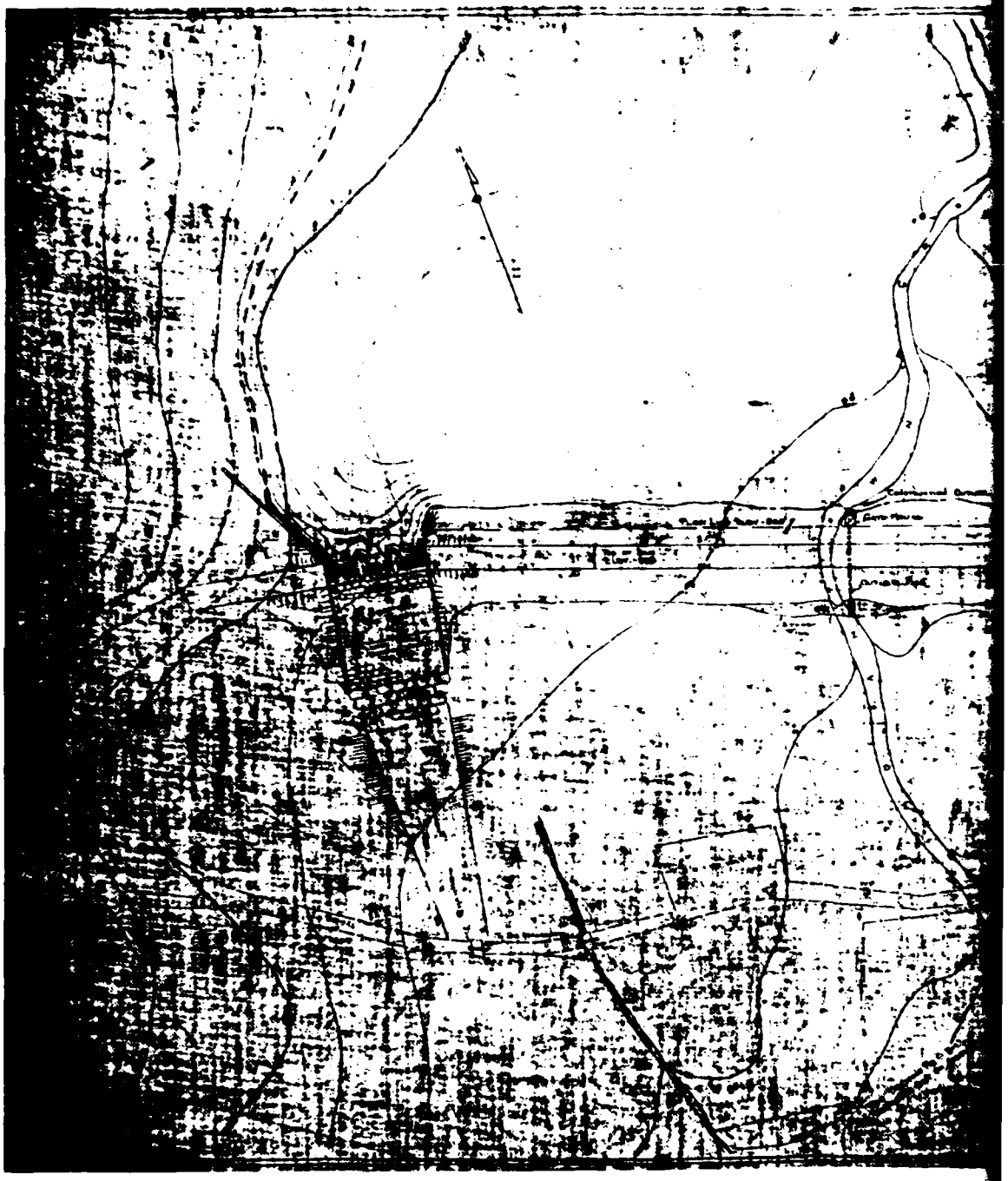
APPENDIX E

FIGURES

LIST OF FIGURES


GRANTVILLE, PA.
NW/4 HUMMELSTOWN 15' QUADRANGLE
N4022.5—W7637.5/7.5
1969
PHOTOREVISED 1975
AMS 5664 I NW—SERIES V831
EAST HANOVER
WATERSHED
RESERVATION DAM
MILITARY TRAIL
UNION
COLD SPRING
DUNLAP
ROAD
TRAIL
MC LEAN
AMMO
Gravel Pit
St Joseph Springs
BM 1298
BM 640
BM 570
BM 444
Creek


INDIANTOWN GAP, PA.
NE/4 HUMMELSTOWN 15' QUADRANGLE
N4022.5—W7630/7.5
1969
PHOTOREVISED 1977
AMS 5664 I NE-SERIES V831
WATERSHED BOUNDARY
LONGEST WATERCOURSE
CENTROID OF DRAINAGE AREA
BLUE
MOUNTAIN
INDIANTOWN GAP
MILITARY RESERVATION
Indiantown Gap
Moonshine Ch
Cem
DUNLAP
CHESTNUT
ROAD
ACORN
FIRST
RANGE
AVE
HUNTING PARK
Muir Field
Gravel Pit
Marquette Lake
RESERVATION DAM
Gap
Indiantown Run
Aires
Indian
RIDDLE
Emmanuel Ch
BOUNDARY
Trailer Park
Vesta
State Memorial Lake
BM 794
BM 727
BM 570
BM 512
BM 476
BM 536
BM 433
BM 444
BM 486
801
810
1256
FIGURE 1
REGIONAL VICINITY
AND
WATERSHED BOUNDARY MAP



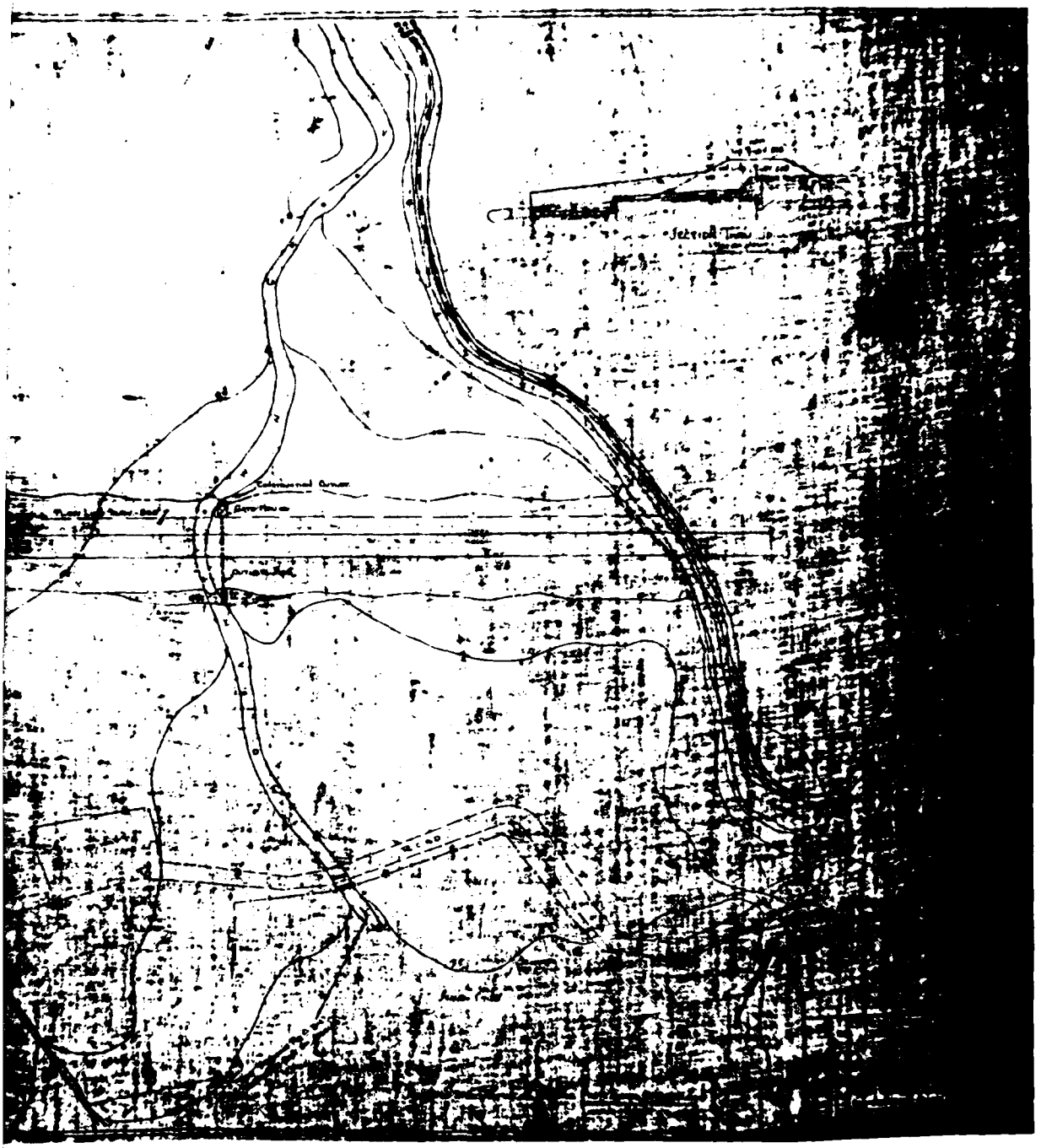


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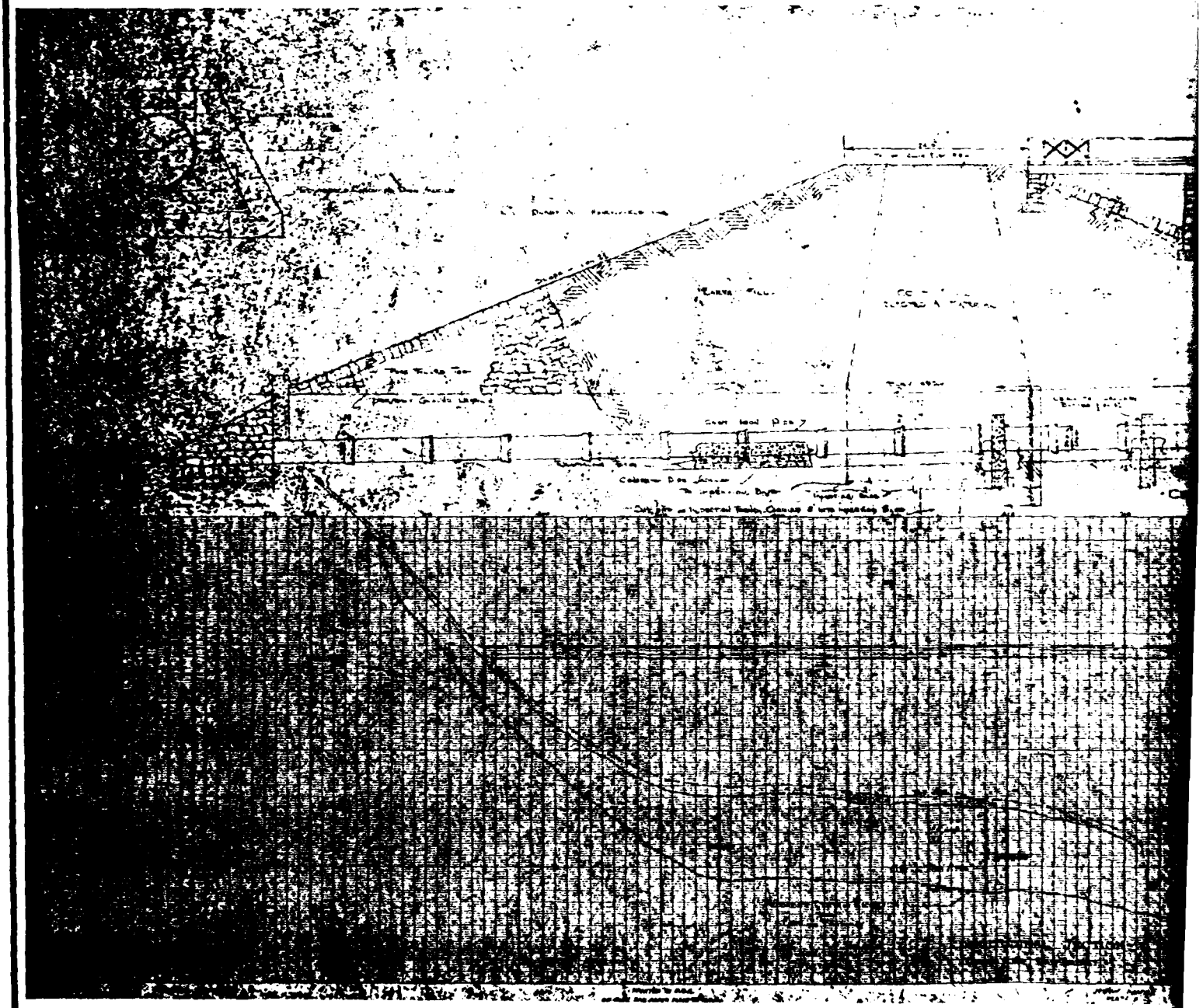
FIGURE 2



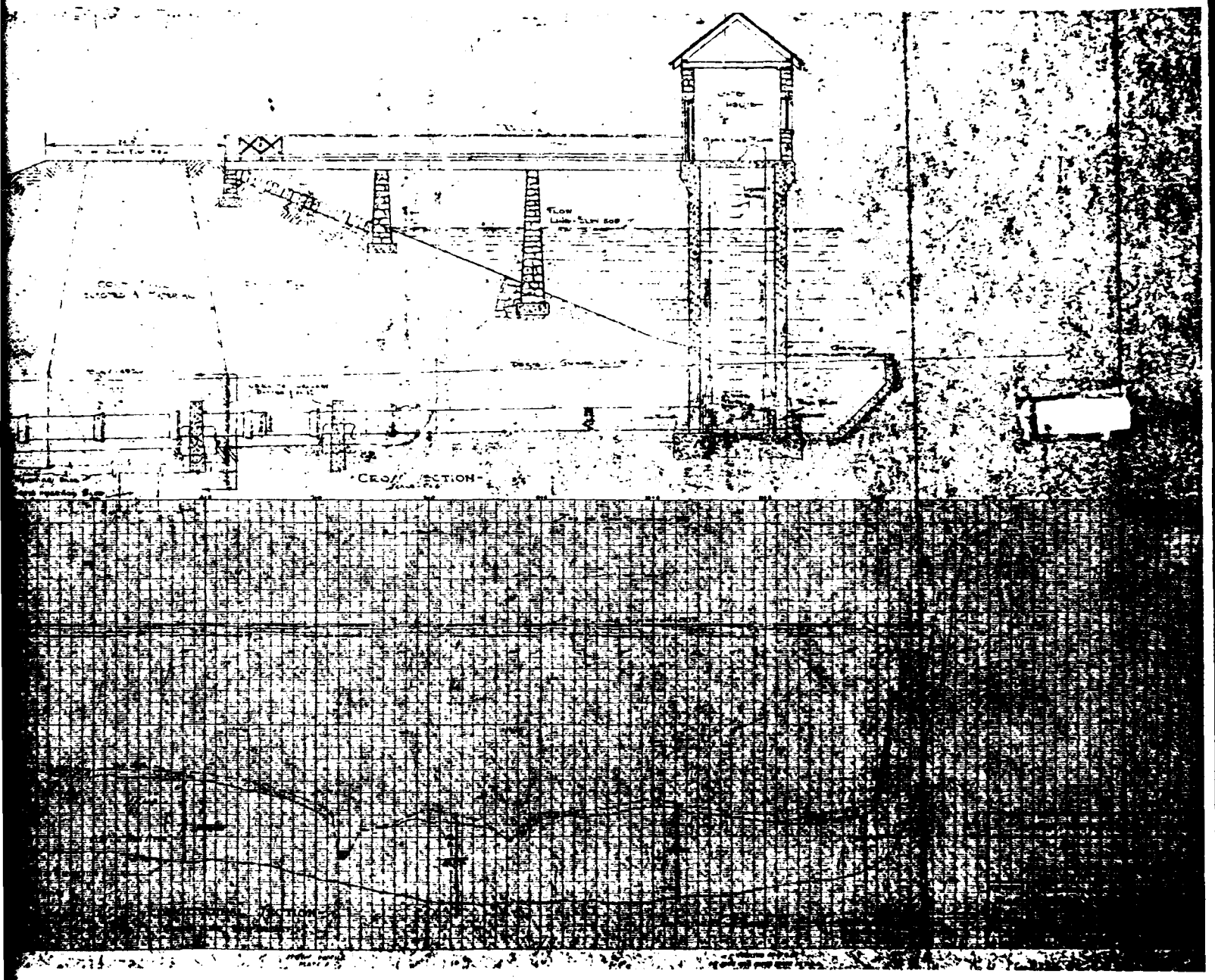


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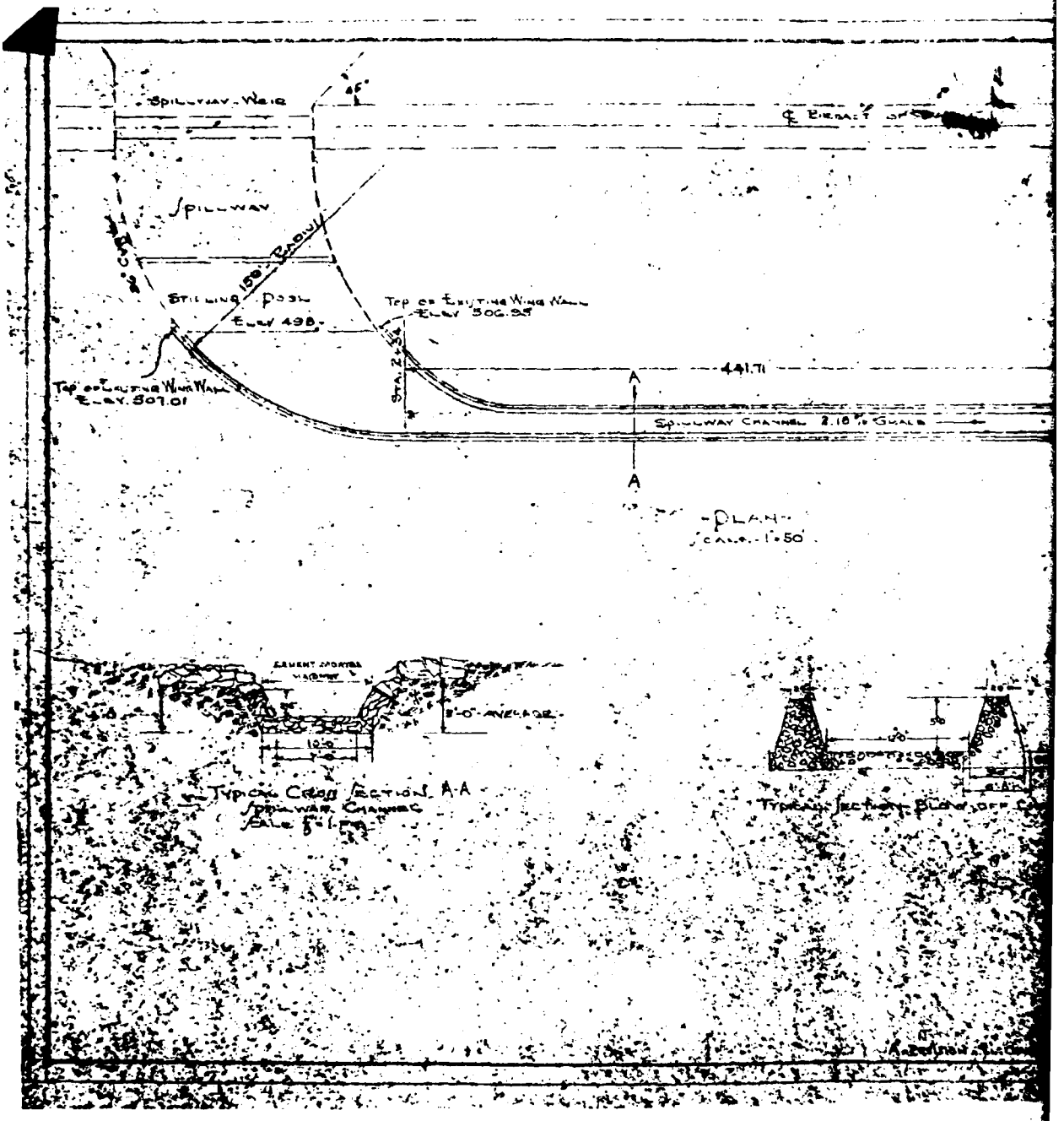
FIGURE 3


Spillway Weir
45°
℄ Dike
Spillway
Stilling Basin
Elev 498
Top of Existing Wing Wall
Elev 506.95
Top of Existing Wing Wall
Elev. 507.01
441.71
Spillway Channel 2.18% Grade
A
A
-PLAN-
Scale: 1"=50'
Easement Boundary
3'-0" Average
Typical Cross Section A-A
Spillway Channel
Scale 5'=1"

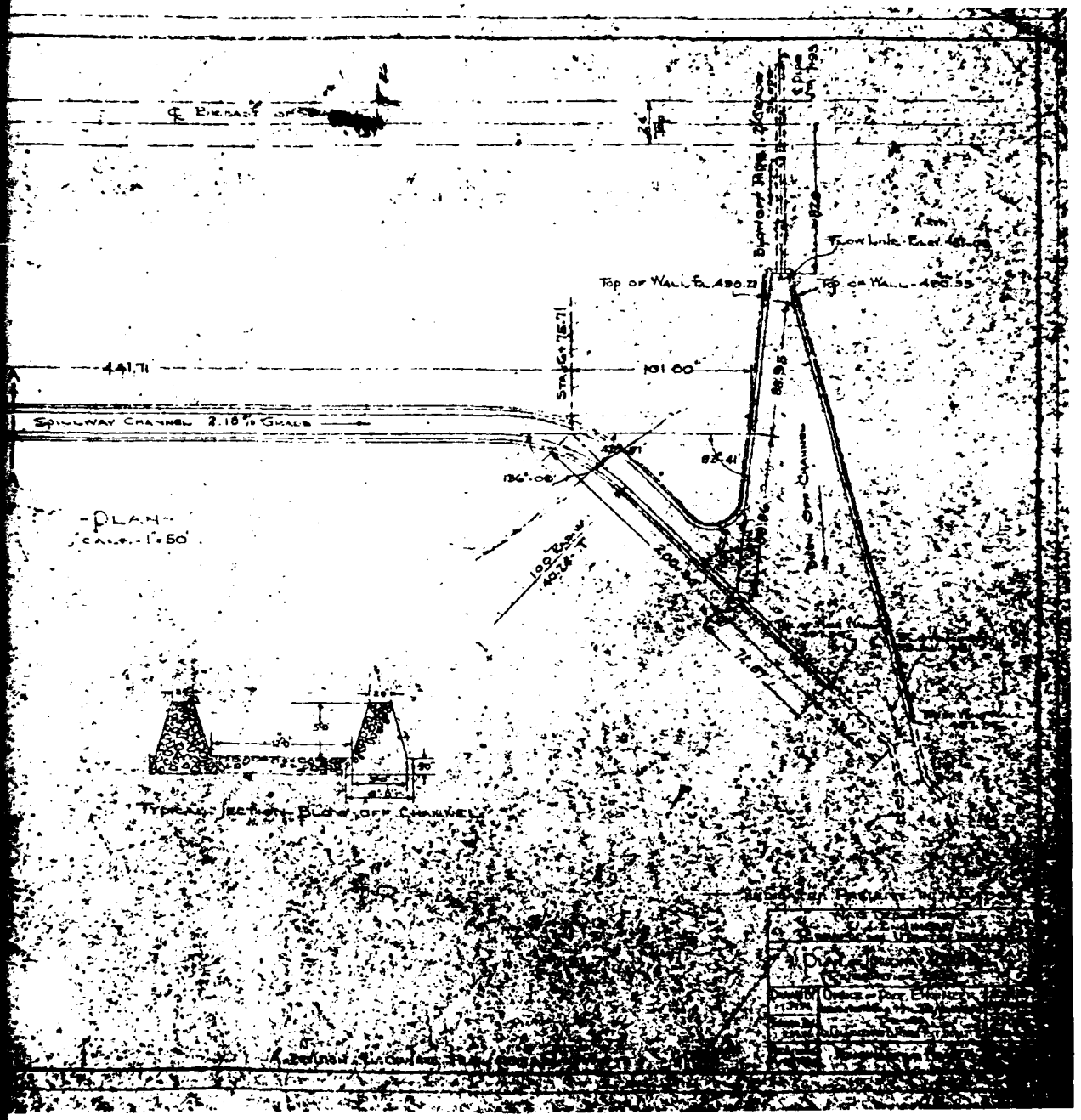


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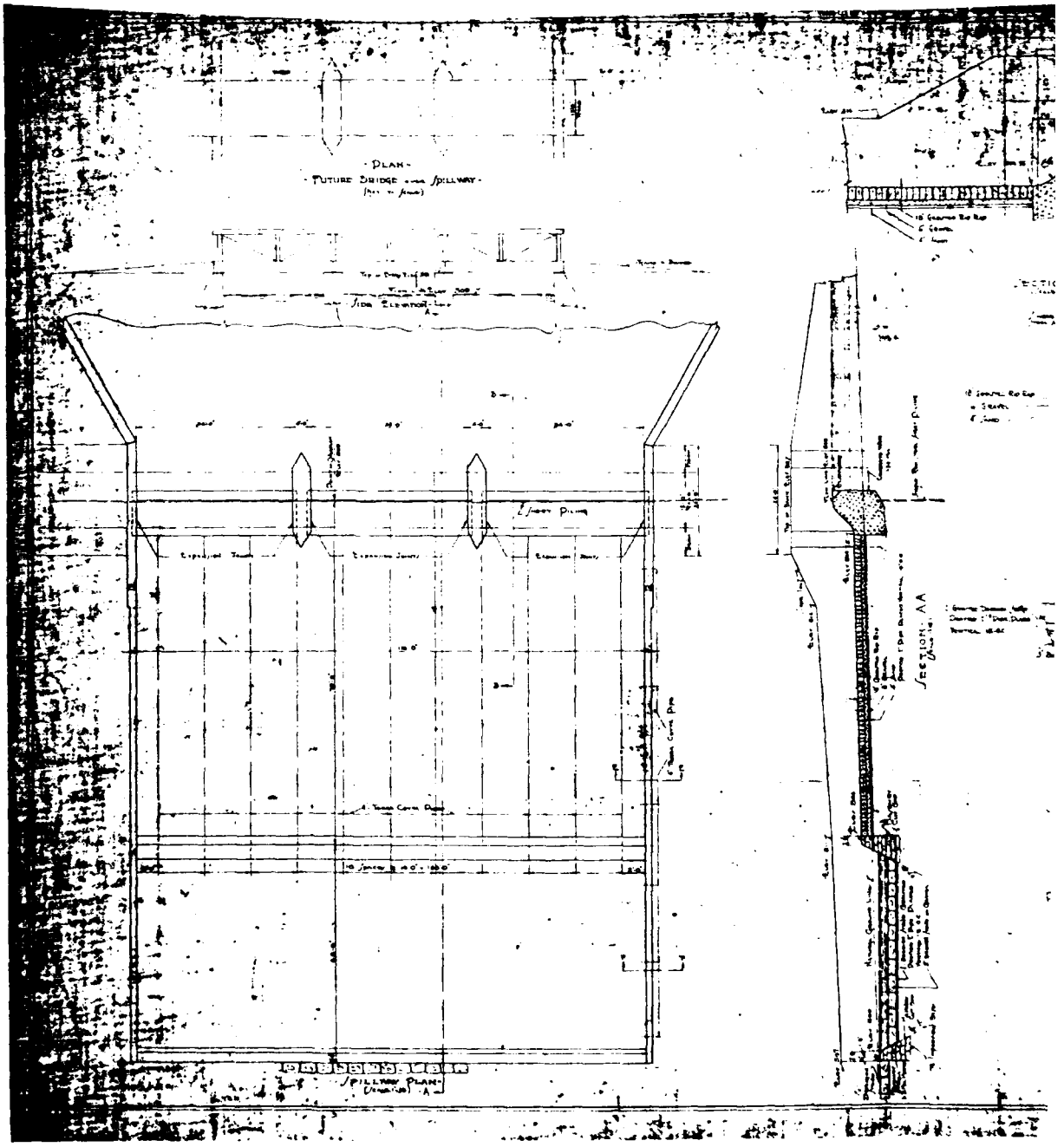
FIGURE 4


PLAN
FUTURE BRIDGE OVER SPILLWAY
SECTION AA

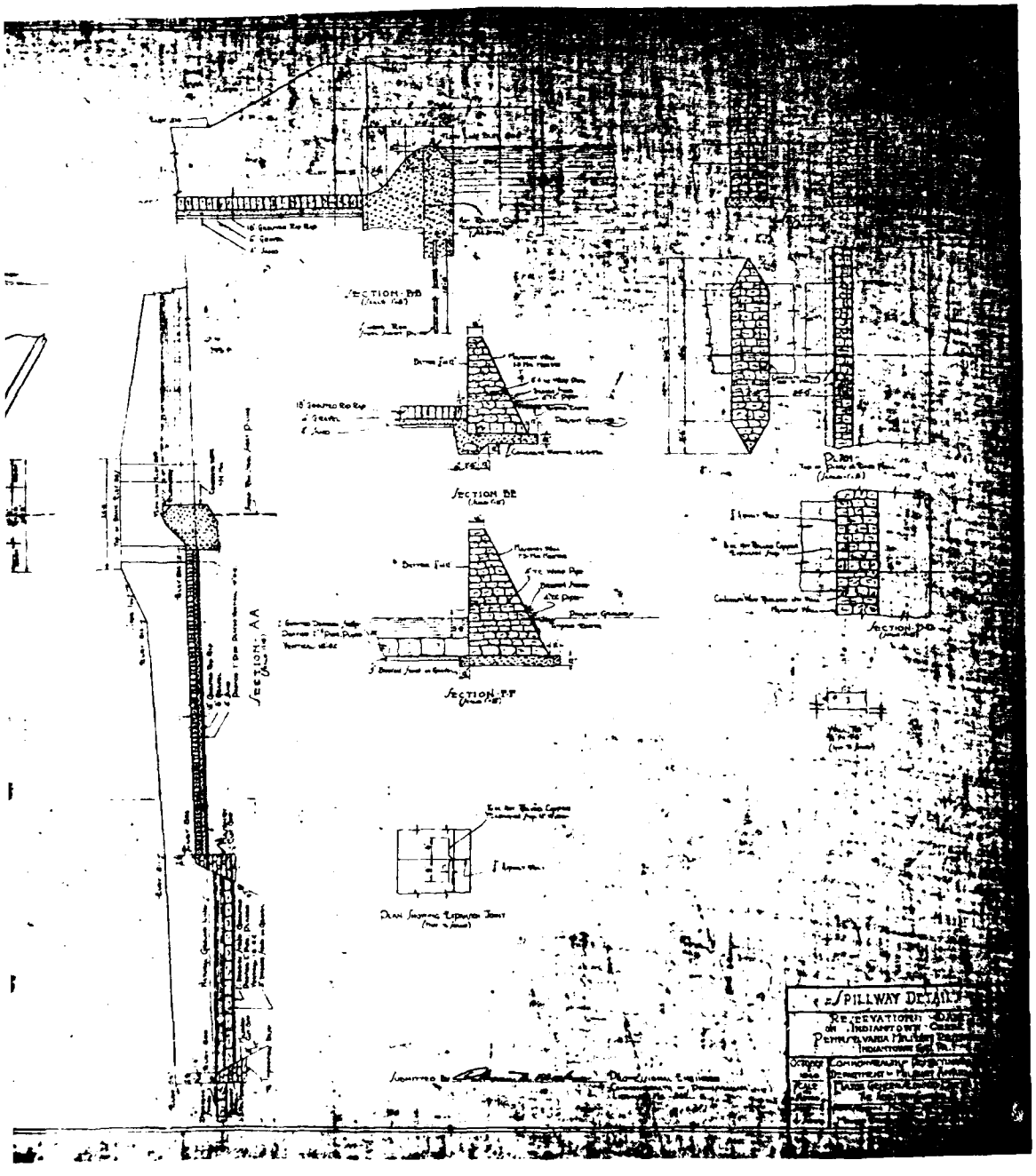


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FIGURE 5

APPENDIX F

GEOLOGY

Geology

Reservation Dam is located on the boundary between the Appalachian Mountain section and the Great Valley section of the Valley and Ridge physiographic province of central and eastern Pennsylvania. The Appalachian Mountain section lies immediately north and west of the dam whereas the Great Valley section contains the dam and lands downstream of the reservoir. Bedrock immediately underlying the dam and also contained within the abutments consists of dark-gray shale and shaly siltstone of the Martinsburg Formation of Middle Ordovician age. The Martinsburg Formation crops out in a northeast-trending belt through central Lebanon County and forms the northern half of the Great Valley section. The Martinsburg Formation is bounded on the north by the disconformably overlying Juniata Formation and the Tuscarora Formation, and on the south by a series of overlapping fault sheets of generally older carbonate rocks apparently thrust onto it.

In the highlands above the dam and reservoir, Indiantown Run passes through a watergap in Blue Mountain and drains a small intermontane valley of the Appalachian Mountain section. This region is composed of a broad band of long, narrow mountain ridges and intermontane valleys which cross the state from the south-central border nearly to the northeast corner. Intense lateral compression from the southeast produced a series of high amplitude anticlines and synclines

whose axes generally trend in a southwest-northeast direction. Folding was followed by uplift. Subsequent erosion cut valleys in the soft nonresistant beds and left the hard, resistant strata as ridges. In several instances, such as at Indiantown Gap, superposed streams cut across the resistant ridges during the course of uplift.

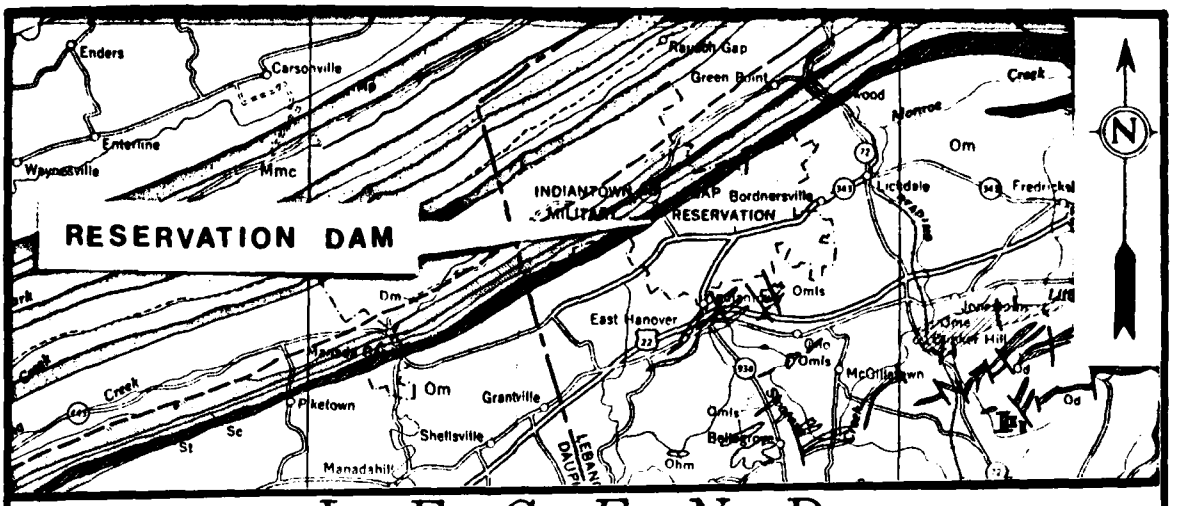
Blue Mountain is composed of the highly resistant Tuscarora and Juniata Formations of Upper Ordovician and Silurian age. The slopes of the mountain, particularly on the Great Valley side, are blanketed with talus or colluvium ranging from five to fifty feet in thickness. This material consists of a mixture of quartzite boulders and shale developed from the underlying Tuscarora and Juniata Formations.

Groundwater in the Martinsburg Formation occurs chiefly in secondary openings in the rock, such as joints and other fractures. Primary openings (the void space between the individual grains of a rock) have been closed in the Martinsburg Formation by compaction and cementation following deposition. Steep-dipping joints and other fractures are the most important secondary openings through which groundwater can flow in this formation.

Carswell, Louis D., et. al., "Geology and Hydrology of the Martinsburg Formation in Dauphin County, Pennsylvania," Pennsylvania Geologic Survey, Groundwater Report W 24, Harrisburg, 1968.

Hall, George M., "Groundwater in Southeastern Pennsylvania," Pennsylvania Geologic Survey, Bulletin W 2, Harrisburg, 1934.

Meisler, Harold, "Hydrology of the Carbonate Rocks of the Lebanon Valley, Pennsylvania," Pennsylvania Geologic Survey, Groundwater Report W 18, Harrisburg, 1963.



L E G E N D

PENNSYLVANIAN

ANTHRACITE REGION

Ppp — **Post-Pottsville Formations**
Brown or gray sandstones and shales with some conglomerate and numerous minecable coals.

Pp — **Pottsville Group**
Light gray to white, coarse grained sandstones and conglomerates with some minecable coal; includes Sharp Mountain, Schuylkill, and Tumbling Run Formations.

MISSISSIPPIAN

Mmc — **Mauch Chunk Formation**
Red shales with brown to greenish gray flaggy sandstones, includes Greenbrier Limestone in Fayette, Westmoreland, and Somerset counties, Loyalhanna Limestone at the base in southwestern Pennsylvania.

Mp — **Pocono Group**
Predominantly gray, hard, massive, cross-bedded conglomerate and sandstone with some shale, includes in the Appalachian Plateau Burgoon, Shenango, Cuyahoga, Cussewago, Corry, and Knapp Formations, includes part of "Oswayo" of M. L. Fuller in Potter and Tioga counties.

DEVONIAN

UPPER

CENTRAL AND EASTERN PENNSYLVANIA

Dck — **Catskill Formation**
Chiefly red to brownish shales and sandstones, includes gray and greenish sandstone tongues named Elk Mountain, Honesdale, Shohola, and Delaware River to the east.

Dm — **Marine beds**
Gray to olive brown shales, graywackes, and sandstones containing "Chemung" beds and "Portage" beds including Rocket, Brallier, Harrell, and Trimmers Rock, Tully Limestone at base.

SILURIAN

Sbm — **Bloomsburg Formation**
Red, thin and thick bedded shale and siltstone with local units of sandstone and thin impure limestone, some green shale in places.

Sc — **Clinton Group**
Predominantly Rose Hill Formation - Reddish purple to greenish gray, thin to medium bedded, fossiliferous shale with interbanding "iron sandstones" and local gray, fossiliferous limestone, above the Rose Hill is brown to white quartzitic sandstone (Keefer) interbedded upward with dark gray shale (Rochester).

St — **Tuscarora Formation**
White to gray, medium to thick bedded, fine grained, quartzitic sandstone, conglomeratic in part.

ORDOVICIAN

GREAT VALLEY

Oms / Ome / Om / Omls — **Martinsburg Formation**
Gray to dark gray, light gray to olive weathering shale Om with thick sandstone interbeds Oms, east of Susquehanna River contains interbedded red shale, gray to brown sandstone, and thin bedded limestone Omls, has associated andesite lavas Ome in Lebanon County.

Scale

0 2 4 6 8 10 MILES

REFERENCE:
GEOLOGIC MAP OF PENNSYLVANIA PREPARED BY COMMONWEALTH OF PENNA. DEPT. OF INTERNAL AFFAIRS, DATED 1960, SCALE 1" = 4 MILES

GEOLOGY MAP

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